VOLUME LIX NUMBER 3 WHOLE 518

SCHOOL SCIENCE AND MATHEMATICS

MARCH 1959

School Science and Mathematics

A Journal for All Science and Mathematics Teachers

All matter for publication, including books for review, should be addressed to the editor. Payments and all matter relating to subscriptions, change of address, etc. should be sent to the business manager.

Entered as second class matter December 8, 1932, at Menasha, Wisconsin, under the Act of March 3, 1879. Additional entry at Oak Park, Illinois, January 18, 1957. Published Monthly except July, August and September at 450 Ahnaip St., Menasha, Wis. PRICE: Four dollars and fifty cents a year; foreign countries $5.00; current single copies 75 cents.

Contents of previous issues may be found in the Educational Index to Periodicals.

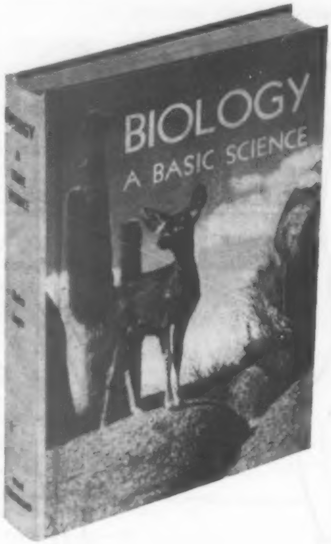
it's perfectly simple!

you really get results with

CHEMISTRY IN ACTION, Third Edition (Rawlins and Struble). The thorough, up-to-date coverage of chemistry keeps students interested and on their toes. The many charts, diagrams, and illustrations are sparked with color for maximum effectiveness. The complete program includes Teacher's Manual, Laboratory Manual and Key, and Tests and Keys.

Another suggestion for your lab—SEMI-MICRO LABORATORY EXERCISES IN HIGH SCHOOL CHEMISTRY, Second Edition (Weisbruch)—the manual that's in step with the trend toward streamlined lab operations.

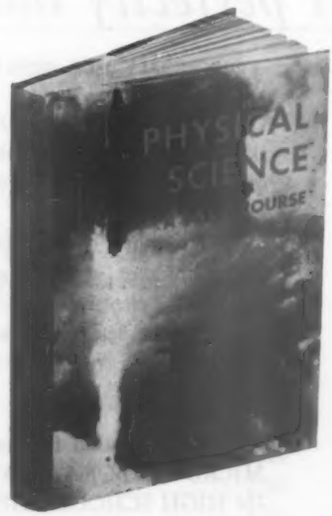
D. C. HEATH AND COMPANY



An excitingly new functional biology

As lively as a student's natural curiosity about the living world, this entirely new 1958 text teaches the basic facts, concepts and principles of biology. It involves the student in hundreds of absorbing activities; the study of biology becomes the exciting adventure it should be. Examine and see for yourself why teachers all over the country are praising *Biology—A Basic Science,* by Heiss and Lape.

A new textbook in physical science



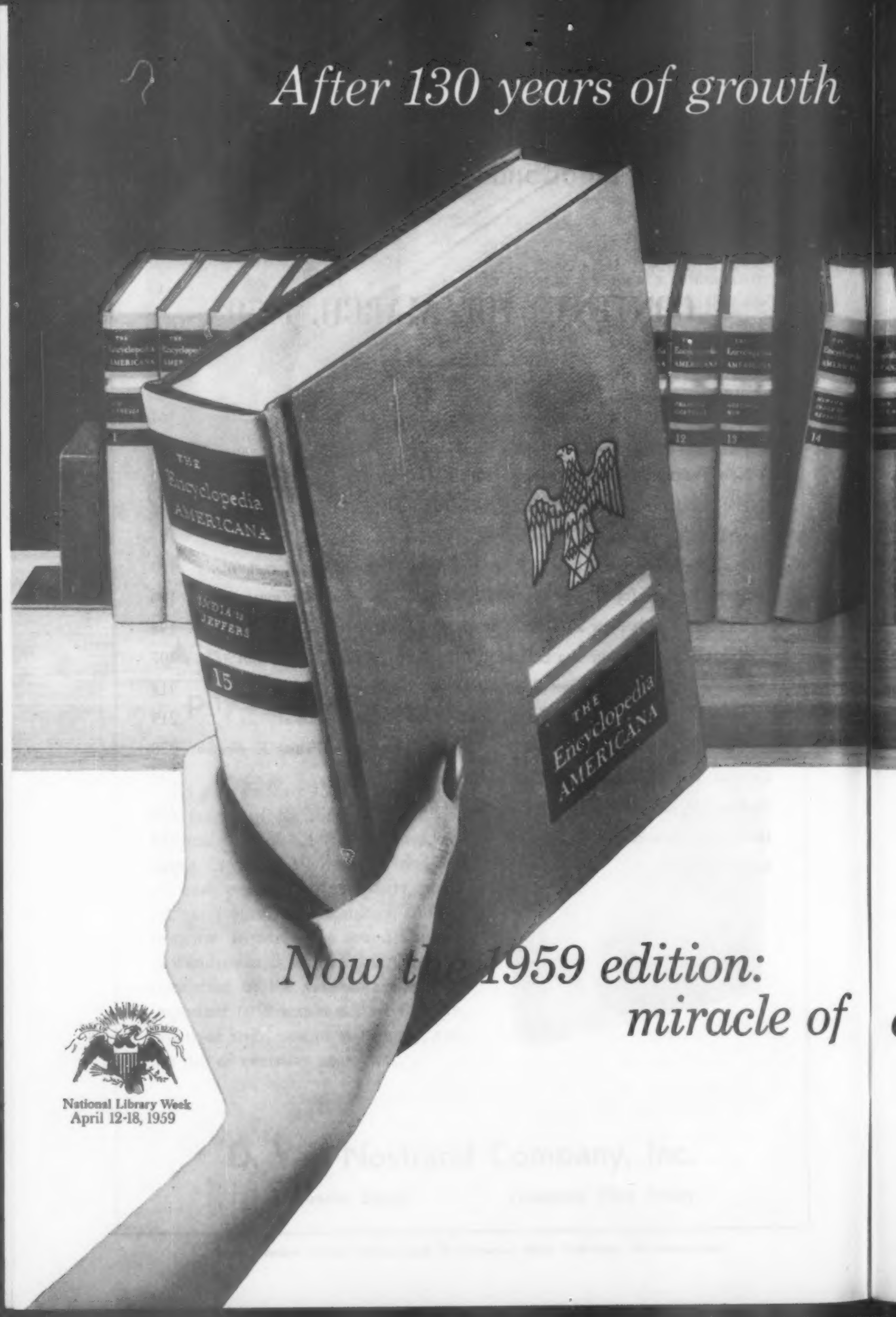
To give students a real grasp of the significance of scientific achievements, *Physical Science—A Basic Course,* by Hogg, Cross and Vordenberg, explores the basic principles of chemistry, physics, earth science, meteorology, and astronomy. It provides a sound training in fundamentals, emphasizing the interrelation of the various fields. This important 1959 text is notable for simplicity of style, ease of vocabulary, and the use of everyday analogies.

D. Van Nostrand Company, Inc.

120 Alexander Street Princeton, New Jersey

CONTENTS FOR MARCH, 1959

Ideas and Chemicals—*Laurence E. Strong* 167
In Memoriam—E. Wayne Gross 171
A New Feature: Elementary Science and Mathematics 172
Cyclic Accelerators—*D. J. Tendam* 175
Easy Does It—*Rebecca E. Andrews* 183
Library Research—A Study in Remedial Arithmetic—*Allen Bernstein* 185
Pictorial Preface for Simple Harmonic Motion—*Moody L. Coffman* 196
The Forest Yields New Products—*E. Garth Champagne* 198
A Scientific Evaluation of a Scientific Program—*Leonard A. Ostlund* 207
Anecdote for Limits—*James C. Bradford* 218
Eggs and Physics—A Class Experiment—*John Satterly* 219
Chemistry: The Pivotal Science in a Liberal Education—*Frank E. Brown* 228
Central Association of Science and Mathematics Teachers 235
Problem Department—*Margaret F. Willerding* 239
Books and Teaching Aids Received 244
Book Reviews 246


After 130 years of growth
THE Encyclopedia AMERICANA
INDIA to JEFFERS
15
THE Encyclopedia AMERICANA
Now the 1959 edition:
miracle of
National Library Week
April 12-18, 1959

CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS—OFFICERS FOR 1959

President—Clyde T. McCormick, Illinois State Normal University, Normal, Ill.
Vice-President—F. Lynwood Wren, George Peabody College, Nashville, Tenn.
Secretary-Historian—Joseph Kennedy, Indiana University, Bloomington, Ind.
Treasurer-Business Manager—Ray Soliday, Oak Park High School, Oak Park, Ill.

EXECUTIVE COMMITTEE FOR 1959

Clyde T. McCormick, President
F. Lynwood Wren, Vice-President
Louis Panush, President for 1958, Mackenzie High School, Detroit, Mich.

BOARD OF DIRECTORS FOR 1959

Ex-Officio

Clyde T. McCormick, President
F. Lynwood Wren, Vice-President
Louis Panush, President for 1958

Terms Expire in 1959

H. Glenn Ayre, Western Illinois University, Macomb, Ill.
Frances Gourley, LaPorte High School, LaPorte, Ind.
Walter E. Hauswald, Sycamore High School, Sycamore, Ill.
Luther Shetler, Bluffton College, Bluffton, Ohio

Terms Expire in 1960

Robert Grubbs, Shortridge High School, Indianapolis, Ind.
Alice Hach, Racine Public Schools, Racine, Wis.
Neil Hardy, Lincoln-Way High School, New Lenox, Ill.
Hobart Sistler, J. Sterling Morton High School, Cicero, Ill.

Terms Expire in 1961

K. Eileen Beckett, High School, Lebanon, Ind.
Robert A. Bullington, State Teachers College, DeKalb, Ill.
Joseph Kennedy, Indiana University, Bloomington, Ind.
R. Warren Woline Oak Park-River Forest High School, Oak Park, Ill.

EDITOR OF THE YEARBOOK

Luther Shetler, Bluffton College, Bluffton, Ohio

JOURNAL OFFICERS

George G. Mallinson, Editor, 535 Kendall, Kalamazoo, Mich.
Jacqueline Mallinson, Assistant Editor, Kalamazoo, Mich.

SECTION OFFICERS FOR 1959

(Order: Chairman, Vice-Chairman, Secretary)

Biology

Morris J. Pumphrey, Arlington Heights High School, Arlington Heights, Ill.
Kenneth E. Robley, Litchfield High School, Lichtfield, Ill.
Robert C. Wallace, Reavis High School, Oak Lawn, Ill.

Chemistry

Gerald T. Alexander, Ball State Teachers College, Muncie, Ind.
Vaughan Armer, Oak Park-River Forest High School, Oak Park, Ill.
Carl J. Engels, Western Michigan University, Kalamazoo, Mich.

Conservation

Rex Conyers, Senior High School, University City, Mo.
Byron Bernard, LaPorte High School, LaPorte, Ind.

Elementary Mathematics

E. W. Hamilton, Iowa State Teachers College, Cedar Falls, Iowa
Alice M. Bauer, Belding School, Chicago, Ill.
Joseph Payne, University of Michigan, Ann Arbor, Mich.

Elementary Science

Ted Wallschlaeger, John Palmer School, Chicago, Ill.
Anthony E. Cordell, Grayling School, Detroit, Mich.
Virginia Tileston, School #68, Indianapolis, Ind.

General Science

Newton G. Sprague, Instruction Center, Indianapolis Public Schools, Indianapolis, Ind.
Rose Lammel, Wayne State University, Detroit, Mich.
Amy Applegate, Bloom Twp. High School, Chicago Heights, Ill.

Mathematics

Paul A. Schuette, Oak Park-River Forest High School, Oak Park, Ill.
Jean Bryson, Twp. High School, Waukegan, Ill.
Thomas Schneider, Cody High School, Detroit, Mich.

Physics

Paul S. Godwin, Thornton Jr. College, Harvey, Ill.
Earl F. Young, Glenbrook High School, Northbrook, Ill.
Ian D. Laing, Shortridge High School, Indianapolis, Ind.

SCHOOL SCIENCE AND MATHEMATICS

VOL. LIX | MARCH, 1959 | WHOLE NO. 518

Ideas and Chemicals*

Laurence E. Strong

Chemistry Department, Earlham College, Richmond, Indiana

Even the casual student of chemistry can hardly help but be aware of the tremendous increase in chemical information which is taking place. Since 1945 the volume of publication in chemistry has been about equal in bulk to all the chemistry on record before 1945. This pattern of expansion has been maintained for at least fifty years. If this geometrical growth continues into the immediate future, a similar doubling of the accumulative total of chemical publication will take place between now and 1971. Faced with the imminent danger of being overwhelmed by the facts in the case, what are we to use as a basis for teaching chemistry to our students?

During the past fifty years or so teachers of chemistry have evolved a pattern for their courses which has successfully presented the subject. Divisions were introduced which recognized matters of major importance. Considerable descriptive inorganic chemistry was presented in the first year college course while the techniques for analysis of inorganic substances were taught in one or more subsequent courses. The many problems of the analysis and synthesis of carbon compounds were sufficiently developed to merit a special course for these.

At the same time the past fifty years has seen the rise of major chemical concepts which have become increasingly powerful. This development has commonly followed a pattern in which a concept

* Paper presented at the Convention of the Central Association of Science and Mathematics Teachers, Indianapolis, Indiana, Nov. 28–29, 1958.

arose in research, then was incorporated into graduate level courses followed by its introduction into undergraduate physical chemistry from where it gradually spread into other parts of the curriculum. Eventually even high school chemistry has altered.

One reason for a chemical concept arising is its power to organize a mass of observations. Thus ideas about atomic structure are tremendously powerful tools for organization. Such an idea may be used in teaching as an organizing principle or may be presented simply as an example of what chemists have developed. Many high school and even college chemistry texts present atomic structure in this latter way without any systematic display of its significance for the correlation of knowledge about chemicals.

During the past two years we have been working on a systematic college chemistry program. Such a program, we conceive of as based on a series of courses each one of which uses a particular major idea as the focus for dicusssion of the relevant descriptive chemistry. An outline of the program has already been published.[1] For the student who takes four years of college chemistry the sequence of courses are listed in Table I.

TABLE I

EARLHAM COLLEGE CHEMISTRY PROGRAM

Year	Lectures	Laboratory
First	Particles of Chemistry	Physical and Chemical Properties
	Covalent Bond	Synthesis and Properties of Molecular Materials
Second	Ions	Preparations and Quantitative Analysis
	Chemical Energy	Thermo- and Electrochemistry
Third	Aromaticity and Resonance	Synthesis and Properties of Conjugated Bond Systems
	Kinetics and Reaction Mechanisms	Qualitative Analysis and Rate Studies
Fourth	Individual Projects	

We are now in our second year of this program. Although this means there is still a considerable distance to go we are satisfied that the change has been for the better. Most of our beginning chemistry students have had some high school chemistry and much of our first year course leads them beyond this start. Student reaction so far is good and it seems increasingly valuable to aid the students' understanding of how modern ideas about atomic structure and chemical bonds can be used to correlate a wide variety of chemical phenomena.

[1] Strong, L. E. and Benfey, O. T., *J. Chem. Educ.*, 35, 164 (1958).

As an illustration of the approach, consider the reaction of sodium metal with chlorine gas to give sodium chloride crystals. The striking feature of such a chemical reaction is the dramatic difference in properties between reactants and products. These differences can be related by pointing out that sodium atoms contain loosely held electrons and that in sodium metal the atoms are held together by the sharing of many electrons among many atoms to give a body centered cubic packing arrangement. Such metallic bonds are fairly strong but not very rigid so the metal has a moderately low melting point but a high boiling point. At the same time the electrons can move around readily within the solid or liquid to make possible a high electrical conductivity.

By contrast chlorine atoms have tightly held electrons in an arrangement which permits the bonding of one more electron to each atom. In this situation chlorine atoms join together in pairs held to each other by the sharing of two electrons thus forming a diatomic molecule. Such molecules have only slight attraction for each other, hence elementary chlorine is a gas at room temperature with fairly low melting and boiling points separated from each other by a short range in which the material is a liquid.

During reaction sodium atoms give up electrons to chlorine atoms so as to make each atom much more nearly inert except for the fact that the atoms are left charged as a result of the electron transfer. The ions, under the influence of powerful electrostatic forces, pack together as spheres into a crystalline solid structure which is hard and brittle and a nonconductor of electricity. In this structure the spheres pack as compactly as possible consistent with charge and relative sizes. Sodium chloride has a quite high melting point, a long temperature range for the liquid state, and a high boiling point. Numerical values for these substances are listed in Table II.

With this rather cursory discussion of a particular reaction system it should be clear that there are a variety of possibilities for developing systematic relations in other reactions. One question frequently raised is concerned with high school chemistry. It is to be hoped that a variety of experimental studies of the high school course will be undertaken. One possibility has been discussed under the title "Chemical Bonds: A Central Theme for High School Chemistry."[2] In this somewhat the same approach is taken as that in the college program described above. It is proposed that the material presented to high school students should be built around a central, major concept in chemistry. In this way the considerable advantage is gained of having a sharp focus for the course which can give a basis for deciding what type of descriptive material can be used most effectively.

[2] Strong, L. E. and Wilson, M. K., *J. Chem. Educ.*, 35, 56 (1958).

TABLE II
PROPERTIES OF SOME SUBSTANCES REPRESENTING METALLIC, COVALENT AND IONIC BONDS

	Sodium	Chlorine	Sodium Chloride
Melting point, °C.	97.5	−102.1	800.4
Boiling point, °C.	892.	− 34.7	1413.
Heat of dissociation, kcal/mole	(25.1)[a]	56.9	101.
Heat of vaporization, kcal/mole	25.1	4.4	40.2[b]
Water solubility, moles/liter	reacts	0.09	6.1[b]
Color	silver	Gr. yel.	colorless

[a] It is assumed that all the sodium atoms dissociate during vaporization. Actually the vapor contains a small fraction of diatomic molecules.
[b] Formula weights are used rather than moles.

Such a course would devote major attention to the atomic structures of the first 20 elements. The reactions among these elements would be treated through discussion of three prototype bonds: covalent, metallic, and ionic. As an illustration of the way in which additional refinements are introduced, polar covalent bonds would be developed and illustrated with consideration of the behavior of water and a few other compounds.

Two conferences have already considered this high school course proposal. One at Reed College in 1957[3] and one at Wesleyan University[4] this past summer. A third conference is planned at Reed College during the summer of 1959 at which it is proposed to prepare preliminary drafts of lecture, laboratory, and demonstration material. With these it is hoped systematic experimentation can be started in the fall of 1959. It will be most interesting if other experimental courses can also be worked out in the near future. Certainly the experimental nature of chemistry as a science ought to suggest the value of an experimental approach to its teaching.

[3] *J. Chem. Educ.*, 35, 54 (1958).
[4] *J. Chem. Educ.*, 36, 90 (1959).

E. WAYNE GROSS MEMORIAL

The E. Wayne Gross Science Scholarship Fund has been established to administer funds received in memory of Mr. Gross. Contributions will be used to set up two scholarships: one for an outstanding science student at University High School where Mr. Gross taught; and one for an outstanding student from the High School Science Institute, established by Mr. Gross in 1956. Contributions to this fund may be sent to the Indiana University Foundation, Indiana University, Bloomington, Indiana. Friends will want to remember Wayne in this memorial for two activities in which he was deeply interested.

IN MEMORIAM

E. WAYNE GROSS
1916–58

It is with a sense of severe loss and regret that the editor reports the death of E. Wayne Gross to the members of the CASMT. Mr. Gross was one of the most valuable and industrious members of the Association during the past decade, having made a number of outstanding contributions both to the *Journal* and to the development of policies for the Association. At the time of his death Mr. Gross was physics editor for SCHOOL SCIENCE AND MATHEMATICS and chairman of the policy and resolutions committee.

Mr. Gross was born in St. George, West Virginia, and graduated from high school in Hopedale, Illinois in 1934. He received his bachelor's degree from Illinois State Normal College in 1940 and his master's degree from the same institution in 1946. He had completed most of his work for the doctor's degree in science education at Indiana University. He taught at Strawn, Illinois, and Blue Mound, Illinois, before joining the Indiana University faculty in 1946. At Indiana University he was chairman of the science department of the University School.

His contributions to science education extended beyond the CASMT. He was co-author of three textbooks for junior high school science, was listed in the current *Who's Who in Science*, and was a member of many national science societies.

He is survived by his wife, Lucile, a third-grade teacher at McCalla School in Bloomington, Indiana.

A New Feature: Elementary Science and Mathematics

During the past few years the membership of elementary teachers in the Central Association of Science and Mathematics Teachers has grown markedly. Their interest in the activities of the Association is evidenced by the large attendance at the meetings for elementary science and elementary mathematics. Many of them also have indicated their wish to have more articles appear in SCHOOL SCIENCE AND MATHEMATICS that are related to science and mathematics in the elementary school.

In view of the wishes of these loyal teachers, special efforts will be made in the future to search for top-notch articles in the areas indicated. The first such article appears below. It is an evaluation scale developed by Rand McNally and Company for textbooks for elementary science. It is the first such scale the writer has seen for science textbooks at this level. A scale for textbooks for high-school science prepared by D. C. Heath appeared in another journal several years ago.[1]

It is sincerely hoped that this new feature will be pleasing to the readers.

THE EDITOR

[1] Vogel, Louis F., "A Spot-Check Evaluation Scale for High-School Science Textbooks." *The Science Teacher*, XVIII (March 1951), 70–2.

CRITERIA FOR EVALUATING ELEMENTARY SCIENCE TEXTBOOKS

(Reproduced by permission of Richard W. DeBruin, Managing Editor, Education Division, Rand McNally and Company)

Author(s) ________________________________

Title ________________________________

Publisher ________________________________

Copyright Date ____________ Number of Pages ________ Grade ________

	Adequate: Yes	Adequate: No	Adequate: Unsure	Superior
Authorship				
1. Are the authors experienced in teaching science at the elementary-school level?	___	___	___	___
2. Have they also had practical experience in curriculum planning and construction?	___	___	___	___
3. Have they prepared a chart for their entire series of books giving evidence of such careful planning?	___	___	___	___
4. Are the books sound in scholarship?	___	___	___	___
Organization				
5. Is there a structural, sequential arrangement of subject matter which will bring unity and significance to a study of each selected topic?	___	___	___	___
6. Is the series organized around actual "Areas of living" subject matter?	___	___	___	___

	Adequate			
	Yes	*No*	*Unsure*	*Superior*
7. Are these areas repeated consistently from grade to grade?	___	___	___	___
8. Does the environment treated gradually expand from grade to grade from the immediate surroundings to the entire world?	___	___	___	___
9. Can the areas treated be justified in terms of probable contribution to the objectives of elementary education in general and science education in particular?	___	___	___	___
10. Does the organization in its structure sequence facilitate a group interrelationship by the very nature of its logical pattern? In other words, does it stress continuity of learning?	___	___	___	___
11. Is there evidence from a clearly planned organization that the series was built on adequate research and practical experimentation on the part of the authors?	___	___	___	___
12. Does the resulting plan provide a balanced treatment of all appropriate fields of science or is there disproportionate emphasis on some fields to the neglect of others?	___	___	___	___
Content				
13. Is the content valid and technically accurate?	___	___	___	___
14. Is the character of motivations, explanations, and illustrations consistent with acceptable principles of learning?	___	___	___	___
15. Is there an appropriate balance between information supplied and experiments provided?	___	___	___	___
16. Do the materials arouse interest and challenge energetic study of science problems?	___	___	___	___
17. Is it apparent that social implications of science are pointed out wherever possible?	___	___	___	___
18. Do the materials help children to observe with interest the make-up of their own environment?	___	___	___	___
Science Readiness and Gradation				
19. Do vocabulary, sentence length, and paragraph length grow gradually from grade to grade?	___	___	___	___
20. Is the subject first introduced through pictures alone, then through pictures and labels, and as a third step through pictures and simple related sentences?	___	___	___	___
21. Is reading difficulty in accord with grade placement?	___	___	___	___
22. Are necessary science words clearly pointed out for special emphasis?	___	___	___	___
Development of Scientific Method and Attitude				
23. Are many opportunities provided for critical analysis, application of principles, discussion, formation of hypotheses and conclusions, independent thinking?	___	___	___	___
24. Are pupils constantly encouraged to put into practice skills in problem solving?	___	___	___	___
25. Are evaluation techniques suggested and is guidance into independent study and experimentation encouraged?	___	___	___	___
26. Do we find many suggestions in content for "search-discovery" activities in other books, in audio-visual aids, and in local environment?	___	___	___	___

	Adequate: Yes	No	Unsure	Superior
27. Is a *balanced* activity program suggested which includes observing, searching, manipulating, experimenting, discussing, recording, checking, setting up hypotheses, and formulating conclusions?				
Illustrations				
28. Do the illustrations stimulate pupils to think for themselves?				
29. Do they suggest experimentation?				
30. Do they encourage observation of actual environment?				
31. Are the illustrations placed on the page so as to enhance rather than hinder readability?				
32. Is the quality of printing and art work superior so that pictures are sharp and clear?				
33. Is variety of illustration provided to maintain interest?				
34. Are there artist's drawings in color and in black-and-white?				
35. Are drawings pleasing to the eye and scientifically accurate?				
36. Are there photographs in color and in black-and-white?				
37. Were the photographs obviously taken for the purpose of illustrating this series of books?				
Teachers Aids				
38. Is an effective plan provided so that teachers may know what has been taught in preceding grades and what will be taught later?				
39. Is there a scope and sequence chart?				
40. If not, would the organization of the series permit the construction of such a chart?				
41. Is provision made so that teachers may know the grade placement of each book but pupils will not?				
42. Is a teachers edition of each book available?				
43. Do manuals provide *practical* helps for teachers?				
44. Are adequate suggestions made for outside readings for teachers? for pupils? for visual aids?				
45. Do the books provide a wide variety of learning aids and teaching devices?				
46. Is provision made for displays and exhibits through which the teacher can encourage continuing pupil interest in science work and equipment?				

ERRATA

In the last two issues of the journal, there have appeared two errors in the placement of illustrations. In the January 1959 issue, in the article on p. 58, entitled "A 3-D Alphabet," the third line of figures (K through O) was inverted.

In the February issue, on p. 156, there appeared on article entitled, "The Spool Problem." Figure 1 in this article should have been twisted in a counter-clockwise direction so that the spool would appear to be rolling on the horizontal.

Cyclic Accelerators*

D. J. Tendam
Purdue University, Lafayette, Indiana

In his retiring address as President of the American Physical Society in 1954, the late Enrico Fermi humorously presented a logarithmic plot of the progress in the development of particle accelerators of ever higher energies. He extrapolated the exponential progress of recent years and proposed that in a few more decades we should build a vacuum tube to circle the earth and, using the earth's magnetic field, reach an energy of 100,000 Bev. But now, in this age of artificial satellites, accelerator designers can have even bigger dreams. Why not put into orbit a ring of satellites, each carrying a section of a gigantic accelerator, and so obtain a million Bev?

In a more serious vein, what is the purpose of the race to build particle accelerators of higher and higher energy? The answer is quite simple: these machines permit us to examine the structure of the nuclei of the atoms that make up our material world. Atomic nuclei are composed of protons and neutrons (collectively called nucleons) bound together by short-range forces which operate over distances of about 10^{-14} cm. High-speed particles can supply the energy necessary to disintegrate the nucleus for the study of nuclear reactions or can serve as probes to study nuclear structure and the properties of nuclear forces.

The amount of energy required to remove a nucleon from a nucleus is called the binding energy of that nucleon; such binding energies are of the order of 1 to 10 Mev, as contrasted with chemical binding energies of atoms in molecules of a few electron volts. Consequently, particles with kinetic energies of a few million electron volts may be used to explore the gross structure of the nucleus. But nuclear physics has pushed beyond this point to the study of the finer details of nuclear structure and even to investigations of the structure of the neutrons and protons themselves. As finer and finer structural details are sought, particles of higher and higher energies are needed as probes.

All particle accelerators are based upon the same fundamental principle: charged particles are introduced into an electric field which exerts a force on them, pushing them to high speeds and energies. It was soon found that simple one-step machines (such as the Cockcroft-Walton voltage multiplier and the Van de Graaff electrostatic generator), in which the ion is accelerated along a tube by a high

* A paper presented at the Annual Convention of the Central Association of Science and Mathematics Teachers, Indianapolis, Indiana, November 27–29, 1958.

voltage between its ends, are limited to a few million volts by electrical insulation difficulties.

Very high voltages can be dispensed with if the particles to be accelerated are made to pass many times through a single relatively small potential so that they gain energy in a series of steps. There are two general methods for doing this. Although the linear accelerator, in which the ion is subjected to a series of accelerations by successive applications of a number of electric fields along a straight line, may become of more importance in the future, it is the circular cyclic machines which have reached the region of ultra-high energies.

The circular motion in cyclic accelerators is brought about by magnetic fields. A magnetic field exerts forces on all charged particles that move through it; the force on the particle is directed perpendicularly both to the field and to the direction of motion of the particle. This magnetic force is consequently a centripetal force which constrains the particle to move in a circular path.

The first of the cyclic accelerators was the famous Lawrence cyclotron put into operation in 1932. In this machine the charged particles, moving under the influence of a constant magnetic field, circulate in two semicircular electrodes called dees returning again and again to the gap between them. Each time a particle crosses this gap it is given a push by the electric field maintained between the dees so that it is speeded up. As the speed of the particle increases, the radius of the circular path, and hence the length of its path between successive crossings of the gap, also increases. Cyclotron operation depends on the fact that the time to traverse the circular orbit in the magnetic field is the same no matter what the radius is, since the increase in speed just compensates for the increase in path length. Consequently, if the voltage across the dee gap is made to oscillate with a frequency exactly equal to the frequency of revolution of the charged particles in the magnetic field, the particles will gain energy each time they cross the gap and spiral out into circles of increasing radius until they approach the periphery of the dees. The beam of particles may be used here or may be extracted through an exit slit for external use.

The successes achieved in the exploration of the gross structure of the nucleus with cyclotron particles are well known. Conditions for nuclear stability have been investigated; many nuclear reaction thresholds have been measured; and a very large number of measurements of the properties of radioactive isotopes have been made. Some clues to the nature of the nuclear forces have been found from analysis of the results of measurements of energy and angular distributions of product particles in nuclear reaction and scattering experiments. Of course, much work remains to be done in this moderate energy region of nuclear physics so that the cyclotron remains an extremely useful

tool. However, some of the results of research with such machines have led to questions which can be answered only with particles of higher energies than can be achieved with the cyclotron.

Cyclotrons of higher and higher energy cannot be achieved simply by building them larger; there is an energy limitation of about 15 Mev for protons. When the charged particles in a cyclotron reach very high speeds, not negligible in comparison with the speed of light, they begin to increase in mass according to Einstein's relativity principles, and so they take a longer time for each successive turn of their spiral paths and eventually arrive at the gap between the dees too late to receive a push from the oscillating electric field. To remove this energy limitation of the cyclotron, a change in design is needed to compensate for the increase in particle mass. How this can be done was pointed out in 1945 by Veksler in Russia and independently by McMillan in the United States a few months later. They proposed two different methods of compensation, leading to two new types of accelerators, the synchrocyclotron and the synchrotron.

In the synchrocyclotron the frequency of the oscillating dee voltage is made variable so that it can be decreased as the mass of the particle, and consequently the time of revolution, increases; in this way the ion is made to arrive at the accelerating gap at the proper times to gain energy. Just as in the conventional cyclotron, the path of the particles is an outward spiral. However, the pitch of this spiral in the synchrocyclotron is very much flatter and, at high energies near the outside of the spiral, amounts to only a few ten-thousandths of an inch. Even with this very small spacing between turns of the spiral, the number of turns the particle must make in order to gain total kinetic energies of several hundred Mev is so large that high-energy synchrocyclotrons must have very large dimensions.

There are about a dozen high-energy synchrocyclotrons in operation today; half of them are located in the United States. The best known is the first one, which was placed in operation in 1946 at Berkeley, California. This machine, which has been used since that time to accelerate protons to 350 Mev, very recently has been modified to raise this energy to 730 Mev. This now surpasses the 680-Mev energy of the protons from the world's largest synchrocyclotron, that of the Soviet Union. This machine, which the Russians call a phasotron, has a 7000-ton magnet with poles of almost 20 feet in diameter.

With the advent of synchrocyclotrons, physicists have been able to push the exploration of nuclear reactions to new limits, uncovering many new and bizarre processes. With projectiles in this range of energy, nuclei can be split into many pieces. The earliest operations of the Berkeley synchrocyclotron showed that the products of bombardment contain large numbers of new isotopes, "chips" knocked

out the bombarded nucleus. This process is called spallation.

The most exciting discovery made with the synchrocyclotron was that of Gardner and Lattes who found that pi-mesons, particles which previously had been observed only in cosmic radiation, were produced when 380-Mev alpha particles bombarded a target. That this discovery was of great importance stems from our belief that the fundamental nuclear force between pairs of nucleons involves the production and absorption of pi-mesons.

Many and perhaps all of the elementary particles can be created through the materialization of energy. According to the relativistic relation between mass and energy, the mass of a pi-meson, about 276 times that of an electron, is equivalent to an energy of 146 Mev. The primary use of accelerators in the 200- to 600-Mev range has been for the production of pi-mesons, and a large share of the research using such machines has been on the properties of pi-mesons and in measurements of interaction cross sections of the secondary reactions in which mesons act as the bombarding agents.

In the second type of high-energy accelerator based on the proposals of Veksler and McMillan, the synchrotron, the relativistic increase in the mass of the accelerated particle is compensated for by using a magnetic field which is increased gradually at such a rate that particles always travel in the same circle. This fixed orbit permits the use of a narrow doughnut-shaped vacuum vessel; in one section of this chamber is a pair of accelerating electrodes across which there is a constant-frequency oscillating voltage like that in the cyclotron. Since the synchrotron needs a magnetic field only near the fixed orbit of the particles, the magnet iron is arranged in a ring of C-shaped sections with the vacuum chamber in the openings; much less iron is required than for an equivalent-sized synchrocyclotron. The synchrotron principle was first used for electron accelerators immediately after the war; there are about twenty such machines in operation, half of them being in the United States.

In today's accelerators of the ultrahigh energy region, the proton synchrotrons, both the magnetic field and the frequency of the accelerating voltage are varied to maintain a constant orbital radius while the energies of the protons are raised to several Bev. Proton synchrotrons are located at the following sites: a 1.3-Bev machine at the University of Birmingham in England, a new 2.0-Bev accelerator at Saclay in France, the 3.2-Bev Cosmotron at Brookhaven National Laboratory, the 6.3-Bev Bevatron at the University of California in Berkeley, and the 10-Bev synchrophasotron in Soviet Russia. A 10-Bev machine is being built at the Australian National University and a 13-Bev accelerator is under construction at the Argonne National Laboratory. Each of these accelerators is a colossal engineering proj-

ect costing millions of dollars. For example, the Bevatron, which cost about $9,000,000, has a magnet weighing 10,000 tons arranged around an orbit radius of 55 ft. 10-Mev protons are injected into the Bevatron from a linear accelerator. During the course of its acceleration to 6.3 Bev, a proton goes around the orbit about four million times, traveling 300,000 miles, more than the distance from the earth to the moon. The Soviet synchrophasotron is still larger, using a magnet of 36,000 tons and an orbit radius of about 92 feet.

Just as the synchrocyclotron became the first laboratory source of pi-mesons, the proton synchrotrons are being used to produce other particles previously found only in the cosmic radiation. These are the various kinds of K-mesons, with masses between those of the pi-mesons and nucleons, and some of the hyperons, which are heavier than nucleons.

The most significant research with the multi-Bev machines has been the search for the negative proton, or antiproton; this elusive particle was finally found with the Bevatron in 1955. Many of the properties of the antiproton were first predicted from theoretical considerations about a quarter of a century ago: (a) it should have the same mass, charge, and spin as the proton except that the charge would be of opposite sign, (b) it should be produced only in a pair with a proton, and (c) it would have only a temporary existence and would be annihilated in an encounter with a proton, with the liberation of energy equivalent to the mass of the two particles. Because an antiproton can be created only in a pair with a proton, the energy needed must be at least the energy equivalent to the mass of two protons, 1876 Mev. But still more energy is required. If a proton-antiproton pair is created in a collision of a high energy proton with another proton, there will be four particles after the collision each with a kinetic energy of about 938 Mev. Thus the minimum bombarding energy required is about 5.6 Bev, an energy within the reach of the Bevatron. By using a clever combination of deflection magnets, Cerenkov counters, and coincidence time-of-flight techniques, Chamberlain, Segre, Wiegand, and Ypsilantis succeeded in definitely establishing the existence of antiprotons, ending the search of many years. Since then the antineutron has also been added to the list of particles created with the Bevatron.

As usual with all discoveries, the advent of the antiproton and antineutron has brought forth many new questions; it seems obvious that accelerators of still higher energy are needed as tools to look for the answers. Larger proton synchrotrons of the conventional type could be built, since in theory there is no limit to the energy they could achieve. But there is a practical limit: the size and cost of the magnet. In the synchrotron the magnetic forces which hold the

particles in their orbit and so prevent their destruction on the walls of the chamber are very weak, so that the vacuum chamber, and consequently the magnet, must be quite large. For example, the vacuum chamber of the Cosmotron is six inches high and thirty inches wide. If the dimensions of the accelerator are increased, as they must be if the particle energy is to be increased, construction of such large magnets would severely tax the technical capabilities of industry and the cost would be formidable.

In 1952 Livingston, Courant and Snyder proposed a way of sharply increasing the magnitude of the magnetic forces which constrain the particles to stay in their orbit. In the conventional synchrotron the lines of force of the magnetic field are bowed slightly outward so that the particles are forced back toward the center line if they stray above or below it. In the new proposal, called the strong-focusing synchrotron, the lines are bowed much more to increase this vertical focusing effect by shaping the pole faces so that the magnet gap is larger at the outer radius; however, this weakens the magnetic forces which keep the particles in orbits of the correct radius. To compensate for the latter result, alternate magnet sectors have pole tips sloped in the opposite direction; this, of course, also weakens the vertical focusing. It turns out, however, that each of the defocusing effects is more than compensated by the focusing of the other sector, so that the beam of particles is confined to a small cross sectional area and the size of the vacuum chamber may be reduced by 10 to 15 times.

The strong-focusing or alternating gradient principle is being used in a new generation of accelerators now under construction: a 3-Bev machine at Princeton University, a 6-Bev machine being built jointly by the Massachusetts Institute of Technology and Harvard University, 30-Bev installations at Brookhaven National Laboratory and the European Organization for Nuclear Research (known as CERN) in Geneva, Switzerland, and 7-Bev and 50-Bev accelerators in the U.S.S.R. The effectiveness of the strong-focusing principle is shown by a comparison of the data on the Russian machines: while their conventional 10-Bev proton synchrotron has a 36,000-ton magnet for an orbit diameter of 185 feet, their new 50-Bev strong-focusing synchrotron will use only a 22,000-ton magnet for an orbit diameter of 1500 feet.

Ideas for machines of still higher energies are under investigation by accelerator designers all over the world. One of the most productive groups is that of the Midwestern Universities Research Association (MURA) with headquarters at Madison, Wisconsin. One of the important contributions of this group is Symon's proposal of the fixed-field alternating-gradient accelerator, which actually is a cyclotron with the magnet poles shaped in spiral ridges so that the magnetic

field produces strong focusing. The FFAG machine has the advantage that it operates continuously rather than in pulses, and so the average beam intensity is increased. The MURA group has computed all sorts of variations of FFAG geometry and has built several successful working models.

Perhaps the most interesting possibility under discussion by the MURA group is the idea of colliding beams, in which two proton synchrotrons are arranged so that their proton beams intersect and the particles collide with each other. In another version of this proposal, the two beams circulate in opposite directions in the same accelerator; a small model using this principle is under construction now. The purpose of colliding beams is to avoid wasting the portion of the bombarding particle's energy which goes into setting the stationary target particle in motion. As mentioned in the discussion of antiproton production, the threshold for production of a proton-antiproton pair is 5.6 Bev even though the mass of the two particles has an energy equivalence of only 1.87 Bev; the major part of the incident particle's energy shows up as kinetic energy distributed among the particles after the collision. This is somewhat similar to the situation when a hammer strikes a stone that is free to move; the heavier the hammer, the larger the fraction of its kinetic energy that goes into moving the stone. Since the masses of high-energy particles increase relativistically as their speeds increase, it is seen that using a multi-Bev proton to bombard a stationary proton is like using a sledge hammer to try to break a pebble. If both the target and the bombarding particle are in motion, more of the bombarding energy will go into the reaction desired.

While Russian designers are also interested in the fixed-field alternating-gradient type of machine, they are also looking into other possiblities. For example, Budker has proposed an accelerator involving the "pinch effect," the basis of the "magnetic bottle" machines which are playing a large role in thermonuclear research. The pinch effect is the name given to the phenomenon in which a very high current in a gaseous discharge is reduced to a very small cross-sectional area by its own magnetic field. Budker's idea is to use the intense magnetic field, produced by the extremely high current in the pinch of an intense electron beam, as the guiding magnetic field for protons in a conventional synchrotron.

The accelerator designers continue to dream and to build. When will it end? Certainly their efforts will not cease for a long time until that day when we understand the nuclear force—the force which binds nuclei together and leads to the concentration of that energy which, as it is released by fission and thermonuclear reactions, plays such an important role in this atomic age. Theoretical physicists are

convinced that we will come to a better understanding of this force only after much more data about mesons are available. The experience of physics leads to the expectation that as experimental data are accumulated regularities will emerge, theories will develop, and the present confused picture will clear. Meanwhile, accelerator physicists are having an exciting time.

REGISTRATION AT THE 1958 CASMT CONVENTION IN INDIANAPOLIS, NOVEMBER 27–29, 1958

In view of some of the worst weather in the history of CASMT, the convention attendance was indeed surprising. The following convention statistics were prepared by Louis Panush, Immediate Past President of the CASMT.

State	Count	State	Count
Alabama	1	New Jersey	2
D.C.	5	New York	14
Florida	3	Ohio	37
Illinois	108	Oklahoma	1
Indiana	202	Oregon	1
Iowa	10	Pennsylvania	2
Kansas	3	South Dakota	2
Kentucky	1	Tennessee	1
Louisiana	2	Wisconsin	24
Massachusetts	8	Canada	8
Michigan	82		
Mississippi	1	Total	524
Missouri	6		

General meeting Thursday night (symposium)	127
General meeting Friday morning (Dr. Hildebrandt, M. W. Kincaid)	231
Afternoon meetings in science and mathematics	279
General session Friday night (Dr. Muller)	286
General session Saturday morning (Dr. Lohwater)	253
Luncheon (Dr. Obourn, Dr. Brown)	192

A letter sent to the President of CASMT contained a comment expressed verbally by many in attendance. The following is a quotation from that letter.

"I had the pleasure of attending your annual convention in Indianapolis, and felt that it was very worthwhile to learn at first hand the fine work being done in the north central states.

Of course I was disappointed, as were hundreds, that airline tieups prevented Dr. Little from addressing the convention, but at that we were lucky to have such a complete program despite the strikes and the weather. The meetings I attended were excellently handled and presented sound discussions of important issues.

Let me congratulate you on the fine programs and compliment you on your management of them.

Sincerely,
(signed)
E. S. Kalin"
Isodore Newman School
New Orleans 15, Louisiana

There is little or no question that the convention was a success.

The Editor

Easy Does It

(Three Demonstrations in Sound)

Rebecca E. Andrews
Woodrow Wilson High School, Washington, D.C.

Three demonstrations in the field of sound requiring apparatus that can be set up very easily are described here.

The first demonstration is a standard one illustrating that sound originates in vibrating matter. However, the exact specification of what must be done to produce a good, high pitch is never stated. The arranging of the demonstration consists simply of placing a saw blade flat on the table so that it projects beyond the edge of the table one inch or less and of securing the blade to the table by means of a C clamp. See Figure 1. When the demonstration is done for the class, the blade should be bent downwards and allowed to spring back. The tone produced is one that pleases the pupils.

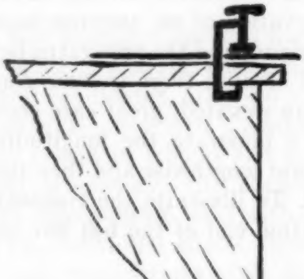


FIG. 1

The second demonstration illustrates the difference between sound insulators and sound conductors. There is laid out on the table a rubber stopper, a wood ball and a metal ball. These should be approximately the same size. A tuning fork is struck with a mallet. After the fork is set into vibration, its stem is placed first upon the table so that the table may act as a sounding board and so that the pupils may hear the sound produced and then in rapid succession upon the rubber stopper, the wood ball, the metal ball, the wood ball again, and the rubber stopper again. See Figure 2. When the tuning fork is placed upon the stopper and balls in this order, the sound is comparatively weak, loud, loudest, loud, and weak respectively. This demonstration also pleases the pupils.

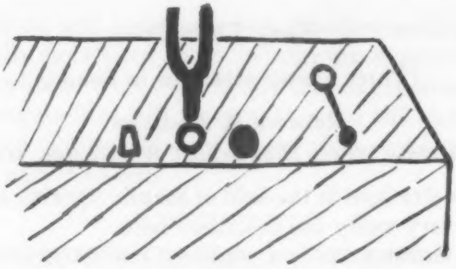


FIG. 2

The third demonstration illustrating the difference between longitudinal and transverse waves is like the first one in that it is a standard one. It, too, can be set up and demonstrated without much trouble. The materials required are two base supports, seven rods, four parallel clamps, two right-angle clamps, a five-foot coil and a six-foot length of fish line. With three vertical rods on each side, as shown in Figure 3, the demonstration can be raised high enough for pupils to see. The elevation of the two top-most rods should not be made until the last minute and the apparatus between periods should be carefully watched because there is some *Danger of Falling Parts* and when the rods are elevated, great care should be taken that all clamps are tight. To illustrate the longitudinal wave the spring should first be held taut lengthwise and then three or four coils compressed and released. To illustrate the transverse wave the teacher should grasp the bottom end of the fish line and move it back and forth rapidly.

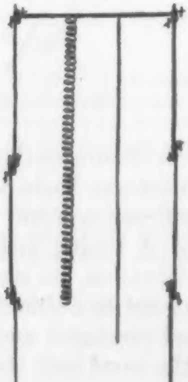


FIG. 3

Library Research—A Study in Remedial Arithmetic

Allen Bernstein
Cody High School, Detroit, Michigan

Critics of research in education have accused it of many inadequacies. Samples are too small; experiments are made under purely local conditions and cannot be generalized; studies made with one age group may not yield conclusions valid for another; factors such as the ability and motivation of the child, and the personality of the teacher have not been properly parceled out, etc. In short, educational research is fragmentary, particularly where actual classroom experimentation is carried out. These comments, when made by professional teachers, come from two sources, those who find criticism a convenient reason for unchanging views or behavior, and those who are honestly seeking to place the conclusions of educational research on firmer ground. While the former constitute a major problem in school improvement programs, it is the latter to whom this article is directed.

To a great degree, educational research *is* fragmentary. The reason is very simple. Those who carry on the work generally live fragmented lives. Most are doctoral candidates, many on a part-time basis, with responsibilites other than their research. Candidates who are full-time students have limited access to schools and to the most important kind of experimental laboratory—the classroom. Some research workers are professors of education, also with other responsibilities. Most of the studies are individual affairs, done with limited equipment, limited funds, and, most serious of all, limited time.

Leaders in educational research are well aware of the problem, and numerous wise solutions have been offered, centered about the use of teamwork in research, made possible by a more favorable financial climate. Projects sponsored by the National Science Foundation, such as the work in revitalizing the high school physics curriculum being done at Massachusetts Institute of Technology under Prof. Jerrold Zacharias, are cases in point. These, of course are the most important approaches. There is, however, another way to place the conclusions of fragmented research on firmer footing—simply add the fragments together.

The reference library is generally regarded as a place to find out what has been done and what conclusions have been drawn. When several dozen experiments, made in the same area, are examined critically, common themes, observations and conclusions may repeat themselves, or be implied, despite wide variations in the dimensions of time, age, location, class size and the like. The author has completed such an evaluation of over 200 articles on remedial arithmetic,

and presents the following review of selected references, with some statements concerning his own experimentation.

The studies reported can be classified in four general areas, each contributing to our general knowledge of remedial arithmetic from its unique standpoint:

A. Remedial Teaching Projects

Such projects have been carried out at all levels of instruction from the third grade to the first year of college, with methods varying from strictly individual teaching to large class procedure.

Blair[5] conducted a survey of 1,090 secondary schools. Of 379 schools returning the questionnaire, 166 described greatly varied teaching programs concerned with remedial arithmetic. The data indicate the growth in awareness of the problem among secondary school people today.

At the primary level, the most outstanding work in the field of remedial teaching generally, and specifically in Arithmetic, has been done by Fernald[12] whose clinic at the University of California has been in operation for 30 years. Her work is on a case study basis, and was used as a principal guide in the author's work at Cody High School, suitably modified for use with adolescents. Space does not permit complete description of her methods, but it is appropriate to list causative factors in arithmetic deficiency which she describes:

1. Mental deficiency—the only reason for unteachability. Conversely, it is argued that the student who cannot learn arithmetic is feebleminded.
2. Reading disability:
   a. Inability to read problems.
   b. Lack of what may be loosely described as "background," such as key word meanings.
   c. Characteristics making difficulty in school adaption.
   d. Emotional blocking.
3. Lack of number concept:
   a. Skill in the basic tables of fundamentals.
   b. Problem solving.
4. Blocking of adjustment by ideational or habitual factors or by emotional responses. It is noted that it is far more difficult to cure a bad habit than to teach where no bad habit exists.

Books on remedial teaching have also been written by Brueckner[7] and Blair[4]. These differ little from Fernald in general principle or detail, although Brueckner's work includes more material dealing with decimal numbers.

Plank[21] reports a summary of twenty-four individual cases of arithmetic failure. The children were taught using the Montessori method and showed significant gains in achievement in a short time. Plank proposes several interesting hypotheses, requiring further investigation:

a. Personality factors are pre-eminent as compared with intelligence or school experience in cases of arithmetic deficiency. Such factors as over-protection by parents, loneliness in the home, parents or teachers with rigid personalities, etc. are submitted as possible causes. Plank says, "Insecure children cannot stand the competitive atmosphere, nor the emphasis on speed, in arithmetic computation classes."

Schmitt[24] reports a summary of thirty-four cases of children normal in their achievement in all subjects but arithmetic. No case of this type has shown a mentally defective child. All such cases were reported to have understood basic number concepts, such as the ability to count up to twenty. Deficiencies were attributed to factors such as ill health (leading to absence), diet, mirror writing due to left handedness, gaps in instruction, and attitudes of the children. This study, dated, 1921, is remarkably consistent with recent reports. Instruction with the Montessori materials brought significant changes in the achievement of the children.

Brownell[6] reports four cases conducted by four workers under his supervision. Using techniques generally consistent with those reported by Fernald, the children showed gains of 1.2 to 2.6 years in achievement in six weeks of instruction.

Becker[2] describes an experiment in remedial work in addition of fractions with a sixth grade class of twenty-two pupils. Diagnostic tests revealed individual weaknesses in fifteen different steps in procedure: remedial teaching was carried out. Large gains in achievement were reported. Nothing is said about the precise method and the reader may wonder whether a meaningful procedure was used.

Tilton[28] reports an experiment in which eighty minutes of remedial work was done with each of nineteen fourth-grade students. The results indicated that even in so short a time, significant results in achievement can be shown.

Fogler[13] reports an experiment in which remedial teaching was done in classes of six. He notes that while the children showed great improvement in their arithmetic achievement, that the factor of greatly improved morale could be rated equally, if not more important.

Wilson[30] reports an experiment by Sweeney in which six children in a fifth-grade elementary homeroom were set aside as a special remedial group. Arrangements were made to teach the arithmetic lesson to this group right after recess. Great gains were shown by all of the children, most of whom could be considered normal by the end of the year. A great buildup in morale was also observed.

Vincent[31] describes a case study of a retarded child taught in a special education class by slow, indivudalized technique, involving many repetitions, and gradually mastering some conception of counting to and beyond 200, getting into basic addition after some basic

number sense has been learned, learning subtraction by handling the cash box in the classroom, a series of processes taking many times longer than with most children. The details of technique will prove valuable to any teacher who works with children of this type.

Risdon[32] describes a case study of a twelve-year-old girl who was advanced in all subjects but arithmetic, in which she had been unable to master the addition combinations. Several previous teachers had worked with the problem, drilled her on the combinations without success, and called it carelessness. The new tutor diagnosed the difficulty as inability to perceive objects in groups, as most people can without training, and indicated that this might be due to neural damage. In order to retrain new nerve passages, colored cubes were placed against backgrounds of contrasting color, and the child received practice in quick recognition of twos, then threes, then combinations of these. The material was gradually made more abstract, and the combinations more complicated. After six months of regular training, she was able to do problems mentally that most children required pencil and paper for, and became a superior student in arithmetic. We believe this technique has implications for the instruction of normal children, and should be investigated.

At the junior high school level, Sister Mary Jacqueline[26] reports an experiment done with eleven seventh grade students from a class of twenty three. They were classified as remedial on the basis of a diagnostic test. The remedial instruction was independent of the normal class work, and was given before or after school. Attendance was voluntary, and the teacher worked on both computation and problem solving. Success was reported for eight out of the eleven children and some progress for two others. Sister Mary Jacqueline reports and values highly changes in attitudes as well as achievement.

Thompson[27] describes a two-year experiment in remedial teaching which began in the 7th grade. A series of pre- and end-test units were prepared in many areas of arithmetic. Work for the pupils was individualized. No student was required to do the work of a unit if his pretest score showed mastery of the subject matter. If he did not show mastery, a series of drills were required of him, with appropriate coaching from the teacher. The experimental group gained 1.4 years in achievement in 10 weeks, compared to .4 years for the control group. The experimental gain for the whole year was 2.6 years. It must be noted that this group was not preselected for remedial deficiencies, but was a heterogeneous group.

At the senior-high-school level, Guiler and Hoffman[15] report an experiment in remedial instruction of 9th grade pupils. These pupils were not placed in special classes but were taught by individualized techniques in the regular mathematics classes, which contained 108

"remedial" students and 130 who were listed as a control group. The experiment followed the usual group of diagnostic and individual practice exercises, based on the deficiencies which showed in the testing, with excellent results.

Guiler and Hoffman[13] also report a comparison of four different mathematics classes, which were compared for their achievement in basic computation. The classes were:

1. Algebra
2. Junior Business Training
3. Applied Mathematics
4. Special courses in which algebra was taught three days a week and remedial arithmetic techniques were used two days a week.

Algebra and junior business training had no effect on arithmetic achievement. The students in applied mathematics showed some improvement. The combination of algebra and remedial techniques showed the greatest improvement in arithmetic computation and the same achievement in albegra as did the students who took five days a week of algebra.

Caporale[9] describes an instructional program at the Bok Vocational Technical School in Philadelphia. Slower learning pupils were segregated and placed in smaller groups with understanding teachers. The procedures and instruction described were similar to those in other studies. It is important to note that this type of work has resulted in higher retention of students above the mandatory school age.

The author[3] conducted a study of remedial teaching procedures with ninth grade students, both in large classes, and with individualized instruction in groups of six. Some of the conclusions are reviewed briefly:

1. The experimental technique with large classes produced significant gains, while the control group did not.

2. Fifty-nine cases were closed in the final phase of the clinical teaching study, and ten were partially completed. The closed cases showed a mean gain of 19.1 points on the Cody High School Diagnostic test, with individual gains ranging from one to fifty three points. The closed cases showed a mean number of 6.0 diagnostic items before instruction and 1.1 items after instruction. All of these figures are very significant.

3. Individualized instruction, dealing with all types of student deficiencies, was much more effective than instruction in large classes with corrective exercises. This was particularly noticeable in those aspects of behavior which can be roughly classified under morale. Gains in self-confidence, liking for mathematics, and citizenship were evident in both situations, but much more so in clinical instruction.

4. A special analysis revealed, that for the entire student body, 79.8% of the deficiencies are found in the following three categories: (slightly less for the remedial group)

a. The use of zero in division and multiplication.

b. The borrowing process in all kinds of subtraction.

c. Understanding and use of the decimal point in all four processes.

5. Some students cannot be required to complete an examination in a specified time without undesirable outcomes. Such students get nervous, make unusually large numbers of random errors, and sometimes regress to earlier patterns of wrong response, even though they know better. The same students, without time pressure, sometimes do very well on the same test.

6. Considering that the large majority of cases taught by clinical methods were dealt with at the symptomatic level, it appears that a teacher does not have to be highly trained in clinical psychology to do this kind of work. Other teachers have participated in the clinical program at Cody High School with excellent results.

7. The concept of the slow learning child must be greatly modified. A large number of the children who took part in clinical instruction were not mentally retarded at all. Remedial instruction made it possible for them to compete with "average" students. The difference between the individual who is generally low in intelligence and the individual who is nervous, insecure, and unable to respond to social pressure, is difficult to tell and little understood. With our present knowledge, it is next to impossible to diagnose a ninth grade child as so retarded that he is unteachable, barring organic complications.

Kinser and Fawcett[19] and others report remedial courses offered to college freshmen on the basis of test scores. All indicate that this kind of work has had limited success at the college level.

B. Error Diagnosis Studies

Many studies in error analysis have been done by Brueckner[7] reported in his book "Diagnostic and Remedial Teaching in Airthmetic," and in many journal articles. Most of the other studies have followed the techniques which Brueckner as laid down.

Grossnickle[14] reports what we consider to be the most important single error study so far. He distinguishes between two types of error:

a. Chance error

b. Systematic error.

He argues that a wrong problem on an arithmetic test does not necessarily mean that the pupil doesn't know how to do the problem. All people make mistakes on operations they understand. What we call systematic errors would lead constantly to wrong results on the same

type of problem. Grossnickle argues, for example, that a student who makes an error in carrying on a multiplication problem may know how to carry. If the student makes an error in carrying on three successive multiplication problems, then he needs instruction in this area. Grossnickle's analysis indicated that most of the errors on a particular arithmetic test are chance errors. This is a very important finding, since many workers doing research of this type have not even attempted to separate the two types of error in their analysis. Many erroneous conclusions regarding "loss of learning," "relearning" and what steps teachers should take about them have resulted.

Schane[22] reports a study in which test papers were separated into three I.Q. classes, to compare errors made by low I.Q. students with other groups. Schane noted that the differences were largely of degree rather than kind.

Guiler[17] made a study of the work of 936 ninth grade students in computation with decimals and percents. The errors in decimals were similar to those described by Brueckner for younger students, with differences in frequency, but not in kind. Guiler observed large areas of failure for the majority of students, as in Type III percent problems. He concludes that school administration and teaching techniques are at fault. The phenomena he has observed are so universal in the experience of classroom teachers, that it is likely that teachers of arithmetic are dealing with something much more fundamental.

Arthur[1] studied the papers of 400 pupils. He noted a discrepancy between the ability to compute and ability to solve problems. While the poor computer will be handicapped in solving problems, the indication is that the two types of skilis are relatively independent.

Davis and Rood[10] reported a study in which 56 pupils were retested five times in two years on the fundamentals of arithmetic. Testing began in the seventh grade. The scores increased, in general, but showed a tendency to level off. They noted certain types of errors on the second test which had not appeared on the same papers on the first test and made careful observations about the reappearance of these errors on subsequent tests. The conclusions about "loss of learning" and "recovery" do not take into account what Grossnickle has said about random errors.

C. Studies in Learning Theory

Bruin[8] reports an experiment in individualized instruction in arithmetic. This was not a remedial study, but an experiment done with seventh-grade classes using children of all levels of achievement. Each child progressed at his own rate and level, kept a progress chart and had access to answer pages so that he could evaluate his own

work. Bruin claims that there is great advantage in the child knowing exactly how much is required. While significant data to evaluate this procedure are not available, the limited data provided point to a promising development.

Scheidler and McFadden[23] report an instructional plan in which seventh-grade children were given strictly individualized instruction, with a large amount of self-checking and self-appraisal. They used the Strathmore Plan, which provides 500 tests and work sheets. The mean gain showed two years growth in five months of instruction.

Myers[20] discusses the significance of systematic errors for elementary teaching, from the standpoint of prevention, as well as cure. Since this work is fairly extensive and important to all elementary teachers, it is appropriate to mention a few important conclusions:

1. The earlier systematic errors are corrected the better.
2. After a child has learned correct responses, he may regress to an earlier error under some conditions.
3. Emphasis on speed results in a loss of accuracy. Emphasis on accuracy and real control of the subject matter will increase speed.
4. Current teaching is likely to consider a wrong answer as better than no answer, since the student tried. Diagnosis of much data reveals wrong responses made in order to try something. The risk is that of forcing a poor response pattern to become part of the nervous system of the individual, making future correct teaching more difficult.

Harvey[18] discusses an experiment concerning one particular factor in diagnosis, namely the lack of understanding of zero in multiplication. A diagnostic test revealed many students who misunderstood the nature and use of the zero placeholder. He classified four types of misunderstanding:

1. Multiplying by zero.
2. Misunderstanding the nature of place value.
3. Errors in carrying.
4. Too few or too many placeholders.

Reteaching resulted in a great reduction in the number of errors, and a great increase in the number of pupils with no errors.

Schonell[25] reports that clinical observations indicated normal emotional reactions are more necessary than normal intellectual ones in the teaching of arithmetic.

Tilton[29] reports an experiment which attempted to see if environment could change the place of arithmetic in the educational profile. Six different teachers were encouraged to give special attention and encouragement in arithmetic to selected children in their classes. After several months, the achievement of these children was remeasured and the relative position of arithmetic was examined. Al-

though Tilton is more cautious, we draw the conclusion from his data that environmental factors, particularly the teacher-child relationship, have a large influence, positive or negative, on the relative position of arithmetic in the educational profile.

Summary

1. The causative factors in arithmetic deficiency as described by Fernald[12] are consistent with the observations, procedures and results of every study described. While some obsververs have said little, if anything, about emotional and physical factors, the data describing the results indicate that the factors were there and, quite often, effectively dealt with.

2. A large variety of teaching experiments have been described, embracing a variety of organizational forms, ranging from individual case studies through work with pupils in small groups of four to seven, running the gamut up to group techniques with large classes. It is amazingly apparent that all of these procedures have produced some good results. Through these diversified practices teachers should seek the elements which were common to all, and can be postulated as essential to successful remedial teaching. Two elements emerge from this examination:
   a. Every experiment used individual diagnosis, and lesson plans based on the diagnosis as a basic teaching approach.
   b. The nature of more individualized teaching is bound to bring about a higher order of effective pupil-teacher relationships.

3. In spite of the difficulties in error diagnosis caused by the need for separating systematic and random errors, certain areas of error emerge as common to all studies, and probably to all teaching situations:
   a. Errors in the use of zero, both as a place holder in multiplication and division, and other errors such as 8×0 equals 8.
   b. Errors in borrowing in all kinds of subtraction.
   c. Errors in understanding and use of the decimal point in all four fundamental operations.
   d. Errors in carrying in addition and multiplication.
   e. Errors in the tables of fundamental facts.

4. Individualized instruction was more effective than group instruction, not only for remedial teaching, but for the general teaching of arithmetic as well.

Many workers have made qualitative observations regarding attitudes toward arithmetic, self-confidence, and other aspects of behavior loosely classified under morale. Some have noted that these attitudes present a major stumbling block in clinical teaching. Most have noted that gains in achievement lead to great gains in morale.

The author's experience confirms these conclusions, offered as one more indication that the problems of education are only partly the problems of the intellect. They are much more the problems of the human spirit.

Bibliography

1. Arthur, L. E., "Diagnosis of Disabilities in Arithmetic Essentials," *Mathematics Teacher, XLIII* (May 1950) 197–202.
2. Becker, A. L., "Remedial Work in Addition of Fractions," *California Journal of Elementary Education*, X (August 1940), 43–7.
3. Bernstein, A. L., "A Study of Remedial Arithmetic with Ninth Grade Students," School Science and Mathematics, LVI (January 1956), 25–32; LVI (June 1956), 429–38.
4. Blair, G. M., *Diagnostic and Remedial Teaching in Secondary Schools*, New York: The Macmillan Co., 1946.
5. Blair, G. M., "Remedial Arithmetic in the Senior High School," *Mathematics Teacher*, XXXVI (December 1943), 346–50.
6. Brownell, W. A., "Remedial Cases in Arithmetic," *Peabody Journal of Education*, VII (November 1929), 100–7.
7. Brueckner, L. J., *Diagnostic and Remedial Teaching of Arithmetic*, Philadelphia: John C. Winston., 1930.
8. Bruin, M. E., "Experiment in Individualized Arithmetic," *School (Elementary Education)*, XXX (April 1942), 704–7.
9. Caporale, J., "An Associated Subjects Program for the Slow Learner." Unpublished doctor's dissertation, University of Pennsylvania, Philadelphia, Pennsylvania, 1952.
10. Davis, R. A., and Rood, E. J., "Remembering and Forgetting Arithmetic Abilities," *Journal of Educational Psychology*, XXXVIII (April 1947), 216–22.
11. Dutton, W., "Study of Teacher Attitudes Toward Arithmetic," *Elementary School Journal*, LII (October 1951), 85–90.
12. Fernald, Grace M., *Remedial Techniques in Basic School Subjects*, New York: McGraw Hill Book Co., 1943.
13. Fogler, S., "Half Pound of Cure," *School Executive*, LXXII (June 1953), 62–3.
14. Grossnickle, Foster E., "Constancy of Error in Arithmetic," *Journal of Educational Research*, XXXII (January 1939), 336–44; XXXIII (November 1939), 189–96.
15. Guiler, W. S. and Hoffman, H. B., "Improving the Computational Habits of Ninth Grade Pupils," *Educational Administration and Supervision*, XX (September 1943), 345–56.
16. Guiler, W. S. and Hoffman, H. B., "Effect of Different Types of Mathematics Courses on Arithmetic Achievement," *Educational Administration and Supervision*, XXIX (November 1943), 449–56.
17. Guiler, W. S., "Difficulties in Decimals & Percents Encountered by Ninth Grade Pupils," *Elementary School Journal*, XLVI (January 1946), 384–93; XLVI (March 1946), 563–73.
18. Harvey, L. F., "Improving Arithmetic Skills," *Elementary School Journal*, LIII (March 1953), 402–9.
19. Kinser, J. R. and Fawcett, H. P., "Arithmetic Deficiencies of College Chemistry Students," *Educational Research Bulletin*, XXV (May 1946), 113–4.
20. Myers, G. C., *The Prevention and Correction of Errors in Arithmetic*, Chicago: Plymouth Press, 1935, pp. 1–72.
21. Plank, E. N., "Observations of Attitudes in Remedial Cases in Arithmetic," *Mathematics Teacher*, XLIII (October 1950), 253–63.

22. Risdon, G. A., "Remedy is Suggested for Math Carelessness," *Clearing House*, XXXI (December 1956), 203–6.
23. Schane, E. B., "Characteristic Errors in Arithmetic Among Three IQ Groups," *Pittsburgh Schools*, XII (March 1938), 155–68.
24. Scheidler, D. and McFadden, E., "Arithmetic—A Road to Happiness," *Ohio Schools*, XXI (February 1943), 62–3.
25. Schmitt, Clara, "Extreme Retardation in Arithmetic," *Elementary School Journal*, XXI (1921), 529–47.
26. Schonell, F. J., "Learning Differences in Arithmetic," *New Era*, IXX (September 1938), 223–7.
27. Sister Mary Jacqueline, "Experiment in Remedial Teaching," *Elementary School Journal*, XLI (June 1941), 748–55.
28. Thompson, R. B., "A Two Year Experiment in Individualized Remedial Teaching," School Science and Mathematics, XLI (February 1941), 125–8.
29. Tilton, J. W., "Individualized and Meaningful Instruction in Arithmetic," *Journal of Educational Psychology*, XXXVIII (February 1947), 83–8.
30. Tilton, J. W., "Experimental Effort to Change the Achievement Test Profile," *Journal of Experimental Education*, XV (January 1947), 318–23.
31. Vincent, L., "Peter is a Slow Learner," *Arithmetic Teacher*, I (December 1954), 24–6.
32. Wilson, Guy M., Stone, M. B. and Dalyrymple, C. O., *Teaching the New Arithmetic*, New York: McGraw Hill Book Co., 1939.

WILMINGTON, ILLINOIS STUDY IN GENERAL SCIENCE

The Wilmington-Lorenzo Community High School in Wilmington, Illinois, recently received a grant-in-aid to study the more effective use of personnel for teaching general science. The project is part of the Staff Utilization Study sponsored by the Commission on the Experimental Study of the Utilization of the Staff in the Secondary School, of the National Education Association and the Ford Foundation.

The project at Wilmington is rather significant. It has long been recognized that few teachers are sufficiently well trained in both the biological and physical sciences so as to be acquainted with all the areas ordinarily taught in general science. Hence, certain areas are frequently slighted. At Wilmington as with thousands of other schools, one of the general science teachers has an excellent background in biological science and the other in physical science. In this study two groups of twenty-five students are being taught by each of the instructors respectively for the full year during which time each instructor covers all the areas in the curriculum. An experimental group of fifty students meets for the physical science units with the instructor well qualified in that area and for the biological units with the instructor well qualified in that area. Over a period of two weeks the group of fifty meets with one instructor for seven out of ten sessions. During the remaining three sessions the group is split and meets for demonstrations and experiments with the instructor to which the students are permanently assigned. At the end of the project an effort will be made to determine which system results in the greater increment of learning.

The project is under the general direction of Superintendent Lester J. Stevens and Mr. Robert W. Jones, Principal, Wilmington-Lorenzo High School. The instructors are Mr. Frank Miller, a graduate of the University of Illinois, and Mr. Walter Plume, a graduate of Northern Illinois University. The editor of School Science and Mathematics is research consultant on the project.

Pictorial Preface for Simple Harmonic Motion

Moody L. Coffman
Abilene Christian College, Abilene, Texas

In the study of simple harmonic motion it is desirable to derive expresions for the velocity and acceleration of a particle from its displacement

$$y = A \sin \omega t \tag{1}$$

or

$$y = A \cos \omega t. \tag{2}$$

Here A represents the amplitude, t represents the time, and ω is 2π times the frequency f. If the student has not reached the derivations of the derivatives of the trigonomertic functions, or if he needs a brief review, the following approach is useful.

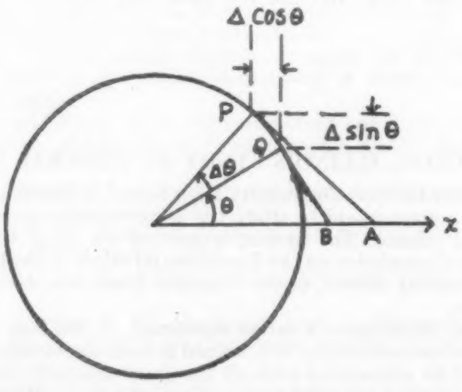


FIG. 1. The unit circle.

Figure 1 shows a unit circle with the pertinent points and angles. The tangent to the circle at P intercepts the x-axis at A, while the tangent to the circle at Q intercepts the x-axis at B. Now the student can see that as $\Delta\theta$ approaches zero, the line segment QB approaches the line segment PA. The student can also be convinced that the arc $\Delta\theta$ can be replaced by the chord PQ in the limit as $\Delta\theta$ approaches zero.

Then, Figure 2 can be drawn to complete the pictures. It follows that

$$\frac{d(\sin\theta)}{d\theta} = \lim_{\Delta\theta\to 0}\frac{\Delta(\sin\theta)}{\Delta\theta} = \lim_{\Delta\theta\to 0}\frac{\Delta(\sin\theta)}{PQ} = \sin\left(\frac{\pi}{2}+\theta\right) = \cos\theta \tag{3}$$

and

$$\frac{d(\cos\theta)}{d\theta} = \lim_{\Delta\theta\to 0}\frac{\Delta(\cos\theta)}{\Delta\theta} = \lim_{\Delta\theta\to 0}\frac{\Delta(\cos\theta)}{PQ} = \cos\left(\frac{\pi}{2}-\theta\right) = -\sin\theta.$$

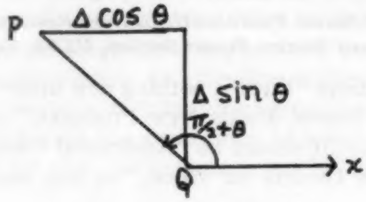


FIG. 2. An infinitesimal triangle.

Derivatives of the trigonometric functions of $a\theta$ may be obtained if the circle is given a radius a. It is true that this approach is somewhat intuitive. However, it is correct and has a firm basis on which the advanced students may rely.

ILLINOIS COUNCIL OF TEACHERS OF MATHEMATICS

Date (1959)	Place	Theme of Conference	Speakers	Conference Chairman
March 7	Greenville		—Dr. Kinney Greenville Coll. —Alexander Calondra Washington Univ. —Reino Takela Hinsdale H.S. —Martha Hildebrandt Proviso East H.S.	Mrs. Laura Mollet Greenville H.S.
March 28	Macomb	"Current Trends and the New Look in Mathematics"	—Dr. Harold B. Fawcett Pres., NCTM —Dr. Glenadine Gibb V.P., NCTM —Dr. Ringenberg Head Dept. of Math. Eastern Illinois Univ. —Dr. Daymond J. Aiken Lockport H.S. —Dr. A. L. O'Toole Professor of Math. Western Ill. Univ. —Mildred Cole Junior H.S. Aurora —Dr. Joseph Stipanowich Head, Dept. of Math. Western Ill. Univ.	Glenn Ayre Western Illinois Univ.
April 11	Normal	"Mathematics for 1960"	—Dr. Howard Fehr Head Dept. of Math. Teachers Coll. Columbia Univ. —Dr. Clarence Hardgrove Northern Illinois Univ.	Francis Brown Illinois State Normal Univ.
April 15	Charleston		—Dr. Francis Brown Illinois State Normal Univ. —Dr. H. C. Trimble Head Dept. of Math. Iowa State Teachers Coll.	Lester Vandeventer Eastern Ill. Univ.
April 18	Arlington Heights	"A New Look at Content and Its Placement"	—Dr. H. Hannon Kalamazoo, Michigan —Dr. H. VanEngen Univ. of Wisconsin	Rod McCleenan Arlington Heights H.S.
April 19	Carbondale			Morton Kenner Southern Ill. Univ.

The Forest Yields New Products*

E. Garth Champagne

Chief, Division of Forest Products Utilization Research Central States Forest Experiment Station Forest Service, USDA, Columbus, Ohio.

In view of the axiom "there is nothing new under the sun" the title of my talk, "The Forest Yields New Products," may be somewhat misleading. Possibly, it should be "Additional Uses for Wood," "Research Brings New Outlets for Wood," or any one of a dozen comparable titles.

In reality, certain phases of my talk may be only a "refresher" course to many of you. But, I do believe there are several new developments in the use of wood and products of the forest that will be of interest.

I recently heard H. L. Mitchell of the Forest Products Laboratory make the statement: "Man has been using wood for fuel, shelter, furniture, tools, weapons, boats, and many of the other necessities of life ever since he descended from the tree tops and first learned to walk on his hind legs." I do not believe any of us will take exception to that statement since it pertained to the use of wood per se. We can all recall illustrations of the cave man swinging a heavy wooden club to gather unto himself a mate, to protect himself in battle, or for other purposes.

As time marched on, technological developments brought new uses for wood in its solid form—either as the pure product of the forest or in some modified condition. Uses were found for bark, fruit and leaves of many species of trees. Oils, tannins, acids and sugars were secured as extractives or derivatives from some or all portions of a tree. But, it is not these generalities that I came here to tell you about today. And, it would take several hours just to name the thousands of manufactured products that contain wood or some material that came from our forests.

As foresters we are interested in the proper management and wise use of our forest land. Forest management starts with the swing of the axe or the start of the motor on a chain saw. That statement may seem to be a new concept to you. Whether or not is new, makes no difference—it is a fact. Keep the axe and the saw out of the forests and they become preserves—and eventually decadent stands of mature and over-mature, insect and disease riddled trees of no value to anyone.

But the axe doesn't swing nor the chain saw hum unlesss there is a use and a market for the products of the forests. We all know that

* A paper presented at the Annual Convention of the Central Association of Science and Mathematics Teachers, Indianapolis, Indiana, November 27–29, 1958.

aluminum and other metals, plastics, and other substitutes for wood are taking the place of millions of board feet of lumber in residential and industrial construction. Wood has been almost completely replaced as a fuel by oil, gas, and electricity for heating and cooking. Thus, many of the old established markets for wood have been lost.

Today the forest manager—to give him outlets for the trees that must be cut in accordance with his management plan, and the wood technologist—who knows the superiority of wood for many applications, are looking for new markets and uses for the products of the forests.

Mr. C. H. Hoffman, Development Engineer, Wood Preserving Division, Koppers Company, Pittsburg, recently said: "Any treatment or process that creates new applications or minimizes wood disadvantages will broaden its markets." I have with me quite a collection of props that illustrate new applications for the use of wood or the products of the forest and miminize some of the disadvantages of wood for certain uses.

Most of the items are the result of basic or applied research— experimentation to find new ways of using the growth in our forests so they can be managed to an economic advantage to the forest land owner; experimentation to provide a product that is superior to a comparable product made from some other raw material; and, experimentation to find uses for logging, sawmilling and manufacturing residues.

For convenience in discussing these items I have separated them into major groups: modified wood, pulp and paper products, glues and joints, particle boards and fiberboards, chemicals, and engineering and miscellaneous developments.

Modified Wood

Modified wood is a material with properties quite different from those of the original wood. The change in properties is obtained by chemically treating wood, compressing it, or a combination of the two treatments.

Wood can be treated with chemicals to increase its decay, insect, fire and moisture resistance; to reduce its tendency to swell, shrink, check and warp; to change its physical properties; and to otherwise improve its suitability for many specific uses where stability, hardness, and durability are desirable features.

Resin-Treated Wood

To stabilize its dimensions, wood can be treated with a thermosetting fiber-penetrating resin that is cured without compression. This process is generally called impregnation and the resulting prod-

uct is commonly known as impreg. Generally it is best to treat veneer and then build up the desired object by laminating multiple layers of the impregnated material.

Impreg is an exceptionally stable product, excellent for making die-models and other products requiring rigid dimensional stability. In the past five years, two of the major automobile manufacturers have started using impreg for their die-models. They claim exceptional savings and closer tolerances in their products as a result of using impreg.

Resin-Treated Compressed Wood

Resin-treated and compressed wood is called compreg. It is similar to impreg, except it is compressed before curing the resin that has been added to the wood. Compreg has most of the improved qualities of impreg and is 10 to 20 times harder than normal wood. In fact, it is so hard it has to be machined with metalworking tools and at metal-working tool speeds.

Compreg has many uses such as silent gears, pulleys, shuttles, bobbins, forming dies, drilling jigs, and instrument bases and cases. You may be using it unknowingly in your homes since it is now used quite extensively for tool and cutlery handles.

Untreated Compressed Wood

Another form of modified wood is commonly known as staypak. It is simply wood that has been compressed under conditions that cause the lignin cementing material between the cellulose fibers to flow sufficiently to eliminate internal stresses in the wood. Since staypak is not impregnated it can be made from solid wood as well as veneer.

It is used where hard tough surfaces are desired such as tool handles, forming dies, furniture legs, connector plates, and picker sticks and shuttles for weaving.

Fire Retardant Treatments

We have always associated wood with fire. Possibly that is because we have always used it for fuel. Certainly that association has been the reason that wood has been ridiculed and even discriminated against as a building material. Numerous city and state building codes prohibit the use of wood for specific types of structures such as schools. However, with the development of fire-retarding chemicals, building codes are being changed to allow use of wood where it was once prohibited.

There are two general methods for reducing the flaming characteristics of wood. One consists of coating wood with paints containing fire-retarding chemicals. The effectiveness of this type of treatment

depends upon the ability of the paint to froth and swell at fire temperatures and insulate the wood from the fire. This method can be used in old or new structures.

The second method provides for impregnation of the wood with fire-retardant chemicals. Borax, boric acid and zinc chloride are common chemicals suitable for imparting fire resistance to wood.

Preservative Treatments

Developments the past few years in chemicals and methods of application to protect wood from decay and insects have expanded the suitability and durability of wood for many new uses. The great expansion in the construction of pole type structures—using preservative treated poles—for farm and industrial use is a good example of how modification of wood has increased its use. Termites are no longer a problem if treated wood is used in critical places.

PARTICLE BOARDS AND FIBERBOARDS

Innovations have been great the past few years in the development of particle boards and fiberboards suitable for many uses.

Particle Boards

Particle board is a comparatively new product made from wood. The boards are composed of small particles of wood or other lignocellulosic particles bonded together with an organic binder. Other names for the boards are "chipboard," "sliver board," "shaving board," and "flake board." As these names imply, the boards can be made of particles of almost any shape.

The boards are made by reducing solid wood to chips, splinters, sawdust or flakes; adding an adhesive; and compressing the mass to the desired thickness and density in hot platen presses or heated extrusion presses.

Particle boards are superior to solid wood for some specific uses. They offer an excellent opportunity to use wood residues from numerous sources thus contributing to more nearly complete utilization of our forest products.

The increase in production of particle board has been phenomenal since 1950. World production that year is estimated as 20,000 cubic meters and in 1956 as 1,101,000. In the United States alone the production in 1958, by more than 50 manufacturing plants, is expected to reach 1 billion square feet on a $\frac{3}{4}$ inch thickness equivalent.

Fiberboards

Fiberboards are manufactured from fibers of wood or other lignocellulosic fiber substances with the primary bond derived from the

arrangement of the fibers and their inherent adhesive qualities.

Generally these boards are of two major types, noncompressed and compressed boards. They are sometimes called insulation and hardboards, respectively. Each has its peculiar qualities and suitability for specific uses. Noncompressed boards are generally used for sheathing, insulation and sound deadening purposes. Hardboards are generally used as a surfacing material.

Glues and Joints

New glues and gluing techniques and new types of joints are bringing about many new uses for wood and paper. Utilization is being improved by making small pieces of wood longer, thicker and wider. I will mention only two items and they may be more evolutionary than revolutionary.

Finger Joints

By cutting of finger joints in the ends of small pieces of wood, applying an adhesive, and compressing the pieces, it is possible to make boards of almost any length. And, all this can be done on a fully automatic machine. Then narrow boards can be edge glued to make any desirable width.

Laminated Beams

In the past high quality trees of suitable species have been available for ship keels and beams for buildings, bridges, and other heavy construction. With the deterioration that has occurred in the quality of our hardwood timber stands this is no longer true. Consequently steel took the place of the heavy wooden beams in shipbuilding and heavy construction. But steel has its limitations. During World War II it was soon learned that steel could not be used in mine sweepers because of the magnetic attraction for metal that was built into some mines. Wood was the only practical practical material to use and as a result of research with glues and gluing techniques a laminated wood beam suitable for use in ship keels was developed. They can be built up of preservative treated boards that will not decay. Now, we also find laminated beams of beautiful curved designs, some with veneer coverings, being used extensively in new schools, gymnasiums, auditoriums, churches, and elsewhere.

And, in passing this subject I would like to point out one additional item. Wood beams now have a higher safety rating than steel girders for some construction uses. The heat of a fire may cause a steel beam to weaken allowing a roof or other section of a building to fall. While wood may burn, it usually burns slowly, chars and retains its structural strength in spite of elevated temperatures. Thus allowing a greater margin of safety for evacuating or emptying a building.

Pulp and Paper Products

Paper is one of the most universally used materials in our economy. The annual consumption of paper and paper board in the United States has increased from 100 pounds per person in 1914 to 420 pounds in 1955. It is predicted that consumption will reach 558 pounds per capita in 1975 and 750 pounds or more by the year 2000.

You are all familiar with the many uses of paper, so I will discuss only a few unusual applications that are causing a substantial increase in its use.

Packaging Material

Corrugated paper, corrugated paperboard and solid paperboard have taken over a large share of the packaging items formerly supplied from solid wood. It is practically impossible these days to find a wooden orange crate or apple box for the kids to use for their many applications—wagons, carts, book shelves, dog houses, etc.—that I used them for. I thought of saying "that you used them for" but I suspect there are a lot of you folks who have never seen a wooden orange crate.

Multiple-wall packaging materials of paper are now being used for the protection and shipment of refrigerators, stoves, machines and numerous other heavy items formerly crated in wood.

Paper-base Plastic Laminates

Paper-base plastic laminates are made by compressing together multiple sheets of resin-impregnated paper into coherent solid panels or sheets. You are familiar with them in their use as table and counter tops in your homes, cafes and elsewhere. They come in many decorative patterns.

Molded Pulp Products

When I was a boy, my mother worked in a general merchandise and grocery store. In those days: cookies came in large boxes of about 15 dozen to the box—not in cellophane packages where each cookie has its own individual compartment; fresh-cut meat was wrapped in "butcher paper"—not prewrapped in a clear plastic film on a molded pulp tray so you cannot see the chunk of bone or fat on the underside of the meat; eggs were handed to you in a paper sack, not in a segregated container made of molded pulp.

In recent years there has been a change-over from bulk handling to prepackaging of practically everything—from a half dozen screws to a frozen turkey. This new practice has created a tremendous increase in the demand for paper and other wrapping materials, paper boxes and specially designed molded pulp products.

Roofing and Sound Deadening Felts

Other uses for wood pulp, that have been increasing rapidly in recent years, are roofing felts and asphalt shingles, and sound deadening felts such as that used on the hood and in the bodies of automobiles.

Chemical Utilization of Wood

It is only within the past 5 to 10 years that research has broken some of the barriers to production of chemicals from wood.

There are enough new developments in the chemical use of wood to require my entire allotted time to discuss. I am not going to discuss all of the developments for two reasons, first because of the shortage of time, and second—and probably the most important—I'm not a chemist. I would like to call your attention to a few items, tho.

Some of the more important and common chemicals and unusual products secured from the forests, either as derivatives or extractives, are: lignin; acetic, lactic and gluconic acids; ethyl, methyl and butyl alcohols; vanillin-synthesized from lignin and used for flavoring; butylene glycol; chemical cellulose; tannins; dyes; oils; naval stores; chlorophyll; ascorbic acid; gum; charcoal; wood sugars and molasses; and yeasts.

Most of the current supply of furfural, one of the major constituents of nylon, comes from oat hulls as a byproduct of the oatmeal industry. However, furfural can be produced readily from xylose, the major component of wood hemicellulose. It is also reported possible to produce—dibasic acid from levulinic acid, the end hydrolysis product of glucose, the main constituent of wood cellulose. Thus, both components of the nylon molecule, furfural and dibasic acid, are potential products from wood or wood residues.

Current indications and predictions are that the production of chemicals will become a major use of the forests within the next twenty years. We will welcome this development as a means to attain full utilization of a renewable natural resource. Possibly the day when we will use "everything but the rustle of leaves" is not too far in the future.

Engineering and Miscellaneous Developments

The final group of items I plan to mention possibly could have been discussed in some of the earlier categories. However, since most of them involve one or more of the other subjects I like to think of them as a separate group. They might be logically considered as developments in the fields of physics and engineering.

Paper Overlays

One method of up grading the quality and improving certain characteristics of wood is to cover the surfaces with paper. By selecting

the proper types of treated or untreated paper and gluing them to the wood with the correct adhesives we can provide products that are suitable for a wide range of special uses. The paper covering hides the defects and discolorations, stabilizes the wood reducing shrinking and swelling, provides a smooth surface with good paint holding characteristics, practically eliminates splinters and slivers, and gives us a product of many uses.

Wide beveled siding can be made from narrow boards held together with a thin layer of plywood or veneer. A paper overlay on the exposed face provides an excellent surface for painting.

Knots and other defects can be covered, as illustrated with these samples of paper overlaid pine and cottonwood, and provide a board with customer appeal.

Even the little used hickories can be covered with paper to make them usable in many places. Loose knots or knot-holes can be drilled out and plugged before the paper is applied.

Paper overlaid plywood is proving exceptionally good for signs and other special uses.

Veneer

New developments in cutting, drying and applying veneers have created many additional applications for wood.

Wood can be sliced paper thin for special use, like this yellow poplar that is only two hundredths of an inch thick. Or it can be sliced $\frac{3}{8}$ of an inch or more in thickness like this piece of oak. Then we can take a clear piece of the thick veneer, glue it to a piece that has some defects in it, and we have a nominal 1 inch board that is suitable for use where a clear face is required.

The denser hardwoods such as oak, maple, ash and this sample of hickory, can be sliced into veneer about $\frac{1}{8}$ inch thick. It can be cut into random widths and lengths and used for flooring by laying it in the proper type of mastic or cement.

Parquet and Block Flooring

Small pieces of wood that are wastes from the manufacture of other products can be assembled into blocks for parquet type flooring. This particular block is black walnut held together with a rubber type cement applied to the back of the block.

Other types of block flooring can be made from small pieces of maple, oak or other dense species held together with small hardboard splines on two ends.

Honeycomb Construction

A rather unique principle of construction that has been developed in recent years is honeycomb or sandwich construction.

By making paper cores somewhat similar in design to the natural honeycomb pattern made by bees, it is possible to provide a material that is light in weight, strong and adaptable to numerous uses. Paper honeycomb cores with veneer, plywood or hardboard faces are suitable for partitions. Honeycombs of the proper thickness can be used for table and counter tops when one face is covered with a decorative paper base plastic laminate. By using the proper principles of design, honeycomb cores can be used as floors, walls and other structural units in buildings.

Light weight wood such as balsa, noncompressed fiberboard and other materials can be used as the core for sandwich construction. Even metals can be used for the faces.

Other Uses

It has been suggested that wood may be superior to metals for space missiles, fast rocket- or jet-powered planes, and earth-satellites. Wood does have some qualities in its favor for such uses. It has high heat resistant properties. It tends to char instead of burn when subjected to friction and its low thermal qualities protect against changes in temperature.

While wooden pipes are not new their use for carrying acids, corrosive materials and wastes from industrial and atomic energy installations is increasing.

Bamboo is being used for reinforcement of concrete beams and pavement. Large electric transformers are now being lined with hardwood lumber and the use of lumber in pallets and cooling towers has been expanding rapidly. It is estimated that 40 million pallets will be used this year.

PROPOSED AMENDMENT

According to the By-Laws of the Central Association of Science and Mathematics Teachers, all proposed amendments to the By-Laws must be published in two successive issues of SCHOOL SCIENCE AND MATHEMATICS to give the membership an opportunity to express its views to the Board of Directors. The following revision was proposed at the recent annual convention.
Proposed By-Laws Revision:
Article I, Section IV. DUES:

NEW	OLD
The annual dues of each member of the Association shall be set by the Board of Directors and will be payable in advance. The annual dues . . . the *Journal.*	The annual dues of each member of the Association shall be $3.50, payable in advance. The annual dues . . . the *Journal.*

A Scientific Evaluation of a Scientific Program

Leonard A. Ostlund*

Université de Rennes (France)

Why Evaluate?

This was a frankly experimental program with respect to stimuli as well as subjects. The stimuli comprised special courses and activities which had been arranged for the National Science Foundation's Academic Year Institute at Oklahoma State University, Stillwater, Oklahoma. Likewise, the subjects constituted an unusual experimental group. Under the terms of the Program, fifty outstanding high school science and mathematics teachers were provided with scholarships enabling them to study at the graduate level for an academic year. Rarely has a group of such outstanding high school science teachers been available for research. The effects of these unusual stimuli upon these unusual subjects demanded assessment.

Furthermore, on a practical basis, evaluation was desirable. This Program was a pilot study, which was broadened to include sixteen Academic Year Institutes during the following year. The findings could be used to guide these subsequent Institutes. This experimental approach of the National Science Foundation would be watched with keen interest. Undoubtedly, the results would have important implications for higher learning. Then too, this program alone would cost $255,000 and the sixteen Institutes would cost in excess of $4,000,000. Certainly, an accounting would be due.

Those who were involved in the Program were convinced of the need for evaluation. It is to the credit of all participants and a proof of their dedication to the lofty ideals of science that they cooperated wholeheartedly with the writer during the series of evaluation studies.[1]

Evaluation planning began ten months before the program was instituted for it was the writer's good fortune to be associated with the Program when it was in the blueprint stage. He continued to serve as Evaluation Director although he subsequently transferred to another university. In the writer's opinion, the uniqueness of the Program presented an unparalleled opportunity for systematic research which might prove valuable for science, psychology, and edu-

* Formerly at Oklahoma State University, Stillwater; now Fulbright Visiting Professor of Psychology, Université de Rennes (France), on leave from Kent State Univeristy, Kent, Ohio.

[1] The writer is indebted to the staff, the students, to Dr. James H. Zant, Director, as well as others whose cooperation made this series of evaluation studies possible. The secretarial efforts of the writer's wife facilitated every aspect of the study. However, the instigation, pursuit, and interpretation of these studies was the sole responsibility of the writer. The views expressed are the author's and not necessarily those of the National Science Foundation or of Oklahoma State University.

cation. Obviously, evaluation of this program was both feasible and desirable.

A Philosophy of Evaluation

Evaluation suggests the judgment of progress towards a goal and this pertained to the Program, as well as the students. Moreover, the dual goal of these studies was to gain information which would be useful locally and nationally.

For example, curricular validity, restricted to the local scene, would have been a simple matter. Teacher-made tests could have been used. However, this would incur two limitations. Such tests would be subjective. Therefore, conscious or subconscious bias might render them valueless. Secondly, the results could not be generalized, but would be restricted to the Oklahoma State University campus.

In contrast, the writer's more challenging and ambitious goal was to evaluate the results in a methodological framework which would be applicable locally and elsewhere. Therefore, the techniques, instruments, results, and interpretations were selected, used, and reported with this in mind. At least one important goal of scientific inquiry has been achieved—replication by others has been made possible.

The writer has expressed his willingness to cooperate with those who desire information.[2] Since guidance is inherent in evaluation, if we can learn where we are on the path to a goal, we can do something about it. Other programs of a similar nature will be instituted. It was expected that the present study would provide some orientation.

These evaluation studies may be considered scientific in that they were systematic and controlled, rather than casual and haphazard. The same stimuli were presented to all subjects, e.g., tests, questionnaires, and interviews. Since rapport with the writer was evident, the responses constituted valid and reliable data. Furthermore, the data have been treated statistically in order to gain the quantitative precision which is so essential to scientific inquiry. Additional insight on the subjective level has been obtained from an analysis of the impressions, opinions, and comments of the students.

Overview

The previous reports in which the writer presented the results of his evaluation projects were more descriptive and explanatory. The purpose was to present the rationales and techniques of every effort in detail so that replication would be possible.

---

[2] Further information can be obtained from: Dr. James H. Zant, Project Director, the National Science Foundation's Academic Year Institute, Oklahoma State University, Stillwater, Oklahoma, or

Dr. Leonard A. Ostlund, Evaluation Director, Fulbright Visiting Professor of Psychology, Faculté des Lettres, Université de Rennes, Place Hoche, Rennes (I. & V.) France.

This concluding report will abstract and integrate all previous ones. Positive and negative findings will be summarized. Implications and recommendations will be suggested. Moreover, the reader will profit by reading articles by Dr. James H. Zant, Project Director (5, 6, 7).

The Selection Procedure

The selection of candidates who would profit from the Program was essential. While transcript hours usually constitute valid criteria for admission to graduate school, our situation was complicated by several variables. Some students had graduated from college twenty years ago. Subject matter in science has changed radically within the past generation. As a result, the knowledge of twenty years ago would not equate with contemporary courses.

Moreover, in tabulating credit hours, three hours in basic chemistry and three hours in agricultural chemistry would be qualitatively different, yet would add just as much to a student's total. Was the totalling of hours, regardless of date, or of difficulty defensible? The first study was designed to answer these questions.

Transcript hours were correlated with scores on standardized tests in biology, chemistry, mathematics, physics, and the physics and mathematics sub-tests of a pre-engineering test. The correlations indicated that the physics sub-test of the pre-engineering test was not statistically significant. This test had been included as an extra, since another physics test was incorporated in the test battery. Therefore, this non-significant finding did not affect our evaluation adversely.

The biology test, significant at the 6% level ($P < .06$) missed the generally accepted critical level of 5% significance by one point. The remaining five areas were statistically significant at the 1% level ($P < .01$). Therefore, it was concluded that the selection procedure was valid (2).

The Graduate Placement Procedure

After the candidates had been selected and were ready to participate in the Program an important problem arose. Unless the individuals were placed at optimum levels, the course would be either too difficult or too easy, hence they would not profit from the Program. Transcript hours dictated placement in relatively few cases. For this reason the scores made by each individual on each subject-matter test were converted into percentiles based upon this group of gifted teachers. The writer designed a percentile graph, a profile on which the students' scores were transcribed. This provided the advisor with a practical, visual representation which portrayed the student's performance as a whole, as well as his specific strengths and weaknesses.

These procedures made it possible to advise and place a student at

the proper level, whether novice, intermediate, or advanced. Furthermore, the fact that these tests correlated significantly with transcript hours was accepted as an indication of their validity. These tests were recommended to other researchers since it had taken considerable effort to find appropriate tests at this high level.

Interest Patterns

It was believed essential to ascertain the interests of these students. If their interests were in fields other than science teaching this might affect their motivation adversely.

Therefore, a highly regarded instrument, the Kuder Preference Record, was administered. Examination of the composite interest pattern of the group indicated that our concern was groundless. The Kuder Interest Pattern was exactly that which was listed for Secondary School Science Teachers. The three interests of primary importance in this area were statistically significant at levels which ruled out chance: scientific ($P<.01$); computational ($P<.01$); and social service ($P<.02$).

These results were interpreted as meaning that since this group had the pattern of interests most suited to their profession, this would enhance their motivation. As a result, they could be expected to profit from the Program. Incidentally, no Kuder Interest Pattern of Secondary School Science Teachers based on empirical data has been reported in the literature. When our study is published it will fill this lacuna.

The Students' Individual Evaluations of the Curriculum

The focus of investigation now turned to the students' opinions of the eight courses which had been specifically designed for the Program. This information was obtained by a questionnaire administered personally by the writer at Oklahoma State University (4).

The questionnaire was scheduled for midway during the second semester since substantial research suggests that this is the optimum time. If a questionnaire is given too soon, there is nothing to evaluate. If too late, a "graduation halo" effect prevails. The student overrates every variable because he has weathered the storms.

Each subject was requested to judge every course on a rating scale marked from zero to one hundred and to explain his appraisal. Thus the quantitative rating was made meaningful by a qualitative statement. In order to insure that the directions would be followed, the writer remained during the administration and answered questions. This technique proved effective in a previous study (3).

This meeting was followed by twenty-minute, confidential *vis-à-vis*

interviews which were tape-recorded with the consent of the student. Before the interview, the writer checked each paper and was able to ask questions designed to fill in gaps or clarify ambiguities. The result was enriched data which included answers written on the questionnaires and verbatim statements transcribed from tape-recordings. The mean rating was calculated for each course. These were as follows:

1. Calculus for Science Teachers........................89
2. Fundamentals of Physics #2........................88
3. Fundamentals of Physics #1........................86
4. Education Seminar........................79
5. Biological Principles........................77
6. Modern Mathematics........................72
7. Modern Advanced Chemistry #2........................66
8. Modern Advanced Chemistry #1........................40

In order to understand the reasons for these ratings, it was necessary to examine the explanations. These were coded by the writer according to the underlying theme. All were categorized and a notation was made whether the remark was favorable or unfavorable. A total of 227 unfavorable and 298 favorable remarks resulted. The categories were as follows:

1. Attitude of the professor.
2. Background necessary to profit from the course.
3. Course content.
4. Grading and tests.
5. Laboratory.
6. Student motivation.
7. Preparation and organization of the course.
8. Presentation by the professor.
9. Rate—whether too fast or too slow.
10. Skill or competence of the professor.
11. Text.
12. Practical value.

Only two courses were rated below 70%: Modern Advanced Chemistry #1, which was given a mean rating of 40 by forty students, and Modern Advanced Chemistry #2, which was given a mean rating of 66 by eleven students. Both courses were taught by the same professor. The students criticized his presentations, tests, and grading system. Clearly, this represented a clash of personality, methodology, and goals, for in personal interviews, the students' reactions were quite emotional.

The writer believed it was his function to report rather than to recommend. In the first place, it would be presumptuous of the writer to tell the Staff how to formulate the program, for this was their responsibility. Then too, certain frustrations were inevitable. For example, if the Staff believed that the students should be given a series of rapid and challenging experiences, and the students complained,

the Staff would have to decide the issue. However, the Staff should be made aware of the students' reactions.

THE STUDENTS' COMMITTEE EVALUATION REPORTS

It is desirable to check individual opinions against consensus opinions in order to gain a more balanced viewpoint. Therefore, the writer asked the students to meet in committees to discuss the Program and write one page of favorable and one page of unfavorable comments.

It is important to note that the eight groups, comprised of six students each, were arranged sociometrically. The underlying philosophy of sociometry is that groups arranged on a choice basis tend to excel in group discussion process and products, groups which have been randomly constituted.

Their reports were mailed to the writer and analyzed by him. As was the case with the students' evaluations of the specifically designed curriculum, the statements were thematically tabulated. Seventy-six favorable comments were categorized: The National Science Foundation Program 16; Effects of the National Science Foundation Program 24; National Science Foundation Staff 23; Oklahoma State University 13; Sixty-nine unfavorable comments resulted: The National Science Foundation Program 35; National Science Foundation Staff 24; and Oklahoma State University 10.

A study of the frequencies and themes of the unfavorable comments revealed that the following were most important:[3] unawareness of the needs of high school science teachers (7); insufficient counseling (7); lack of instructions in education seminar (7); distractions, such as tests and meetings (4); overloading of courses (3); poor communications (3); heterogeneity of background in same class (3); and chemistry inadequate (3).

In contrast, these favorable comments were compiled: library facilities (8); adequate financial assistance (6); the Project Director's (Dr. James H. Zant's) patience and consideration (5); broadening effects of the Program (5); training which qualifies one for a better job (5); association with Fellows (5); value of the degree (5); competence of the Staff (4); and adequacy of physical plant (3).

As might be anticipated, some problems were personal, and a reflection of adjustment to graduate school. These were what might be regarded as typical or common. Moreover, it was interesting to note that similar problems were reported by investigators whose subjects were French University students (3).

Again, the writer did not make recommendations. Instead, the

[3] Only comments by at least three committees were included. The number of committees reporting appears in parentheses.

writer suggested that the report should be shared with the Staff and studied with the viewpoint, "These are the students' feelings and opinions about the Program," rather than "This is what is good or bad about the Program."

Of all the evaluation studies, those concerning committee and individual students' opinions were the most limited in that they pertained to the local scene. However, even here, the techniques by which opinions were secured, categorized, and reported should prove equally effective elsewhere.

Overall Program Evaluation

Three weeks before the termination of the Academic Year Institute the students were questioned as follows: "On an allover basis, how would you rate the Program?" This was accompanied by a rating scale, from zero to one hundred. In addition, the students were asked to explain their ratings.[4]

The mean rating was 76. The ratings were accompanied by comments such as "well worth while," "but could be improved," "more advisement needed," "should have more choice of courses," etc. Evidently, the Program was judged favorably. The suggestions concerning changes echo those reported in other sections of this report.

Academic Progress

Up to this point, questions had been asked concerning the choice and placement of participants and their opinions concerning the Program. However, with regard to the impact of the Program, some of the most penetrating questions were yet to be asked. To what extent had the students improved? What aspects of progress could be measured? Could statistical evidence of changes be obtained? College records and standardized tests answered these questions.

An examination of college records disclosed that seven students did not earn a "B" average in graduate school during the first semester and that the grade point average for all students was 3.44. Improvement was noticed, for during the second semester only one did not maintain a "B" average and the total grade point average of 3.71 was evidence of improvement. This increase was attributed to greater familiarity with the situation, as well as greater freedom of curriculum choice.

At the conclusion of the college year, graduate school records were consulted. All but four had completed the requirements for the degree of Master of Science in Natural Science. By the end of the summer session on August 3, all but one had completed the degree re-

[4] The writer designed a questionnaire which was administered and tabulated at Oklahoma State University. The summary, upon which this section was based, was forwarded to the writer.

quirements. Thus official college records provided formal evidence of high calibre academic progress in Graduate School.

Scientific Progress

It was important to determine whether the students had improved in scientific fields. For this analysis, six standardized tests were used.

The goal of scientific efforts to measure changes in performance involves (1) a pre-test, which indicates the degree of achievement before training; (2) a training program; and (3) a re-test. In addition, the scientific value of the before-and-after sequence depends upon three additional criteria: (1) A constant frame of reference—the pre-test and re-test must be the same. In this study the same tests were used at the beginning and at the end of the Academic Year Institute;[5] (2) The measuring instruments must be reliable, valid, and appropriate. These criteria were met, for these tests have been reported favorably in the literature and our study of the correlations between these tests and college transcripts provided further evidence of validity; (3) The tests, results, and interpretations must be reported in such a way that raplication would be possible. This has been done in these reports.

In order to avoid end-of-term fatigue, the writer scheduled the re-tests three weeks before the conclusion of the Academic Year Institute. The statistical design involved analysis by means of randomized complete blocks.[6] The students' scores made at the beginning and at the end of the Academic Year Institute were compared.

In view of the special courses, lectures, activities, and opportunities for interaction between the students, it was believed that the consequence would be a pervasive, challenging atmosphere. It was hypothesized further that this stimulating experience would spread and pervade other scientific fields in which the students had not taken their courses.

Therefore, the changes in performance for every student, in every test, were analyzed statistically. The results supported the hypothesis. Improvement in mathematics was significant at the 2% level of confidence ($P < .02$). Improvement in each of the other six tests: chemistry, physics, biology, scientific reasoning, and the mathematics and physics sub-tests of the pre-engineering tests was significant at the 1% level of confidence ($P < .01$). These favorable changes in the predicted direction were attributed to the generally stimulating experiences.

---

[5] Dr. Harry K. Brobst, Director of the Bureau of Tests and Measurements at the Oklahoma State University, was responsible for the administration of the tests at the beginning and at the conclusion of the Academic Year Institute.

[6] The statistical design was selected by the writer, formulated by Dr. Franklin Graybill, and computed by Dr. Robert D. Morrison, both of Statistical Laboratory Division of the Mathematics Department at Oklahoma State University.

It has been mentioned that some students did not take all of the special courses. Therefore, the second statistical analysis included only those students who took at least one special course in a certain scientific area. It was hypothesized that those who took courses in specific areas would tend to improve in these areas. The results supported the hypothesis, for in every one of the seven tests, improvement in achievement was statistically significant at the 1% level of confidence ($P < .01$).

Both hypotheses were statistically significant at confidence levels which ruled out chance. Therefore, the interpretation was that these gains in scientific achievement were attributable to the specific course, as well as to the more general, stimulating experience which characterized the National Science Foundation's Academic Year Institute at Oklahoma State University.

Evaluation of the Evaluation Director

It seemed appropriate to investigate the role of the writer as Evaluation Director, because the individual's perception of an experimenter may influence his behavior.[7] If subjects mistrust an investigator, they may provide unreliable information. Thus, the value of a study may hinge upon the delicate balance of interpersonal relationships between interviewer and interviewee.

This data were procured by means of a questionnaire and rating scale sent to the subjects. They were instructed not to sign their names. The question was phrased as follows:

> "Rapport is a French word used to describe the atmosphere of an interview. It means that the person being interviewed felt completely free to say what he chose, that he had the feeling that his opinion was accepted and respected, that there was no attempt made to influence him, and that he believed that this information would be used constructively and kept strictly confidential. To what extent was 'rapport' present?"

The mean rating of 91 was accompanied by remarks such as: "unbiased and fair," "time too short," "satisfactory," "enjoyed interview," "top-notch," "I was sure, and am sure now, that none of the information given in the interview was or is to be used against me," "I felt completely free to say what I wished to say," and "tape-recording bothered." Apparently, the writer achieved his goal which was to function as an unbiased observer. Therefore, the questionnaire, interview, and test data may be considered more reliable and valid than would be the case if the subjects had lacked confidence in the experimenter.

---

[7] This data was obtained by means of a questionnaire and rating scale phrased by the writer. It was administered and tabulated at Oklahoma State University. The summary, upon which this section was based, was forwarded to the writer.

Summary of Favorable Findings

1. The selection process was adequate, for improved achievement in every field was evident.
2. The Kuder analysis indicated that this group had the exact pattern of interests necessary to high school science teaching.
3. The placement procedure was adequate. The high positive correlations between transcript hours and test performance provided a complementary basis for judgment concerning appropriateness of placement level. Moreover, the percentile graphs assisted the advisors.
4. The Students' Individual Evaluations of the special curriculum were generally favorable, since the percentile ratings of six courses were 72, 77, 79, 86, 88, and 89. Furthermore, 298 favorable remarks outweighed 227 unfavorable remarks.
5. The Students' committee reports favored the program by a narrow margin of 76 favorable to 69 unfavorable remarks.
6. The overall program rating, with a mean of 76, was above average.
7. Academic progress, as measured by grade-point-average was outstanding since there was an improvement from a mean grade-point-average of 3.44 for the first semester, to an average of 3.71 for the second semester. Moreover, all but one student completed the requirements for the degree Master of Science in Natural Science.
8. In terms of general and specific improvement as measured by standardized tests in various scientific fields, the group's gains were statistically significant for those who took certain subjects, as well as for those who did not. This was attributed to the specific courses and the general atmosphere.
9. The mean rating of 91, of the Evaluation Director, provided evidence of rapport between the writer and the students. This, in turn, enhanced the reliability and validity of the data.

Thus the subjective opinions of the students, as well as their objectively measured performance, provided evidence of a successful program. In this analysis, qualitative aspects, such as opinions and feelings corroborated quantitative data, such as ratings and test scores.

Summary of Unfavorable Factors

A survey of unfavorable aspects revealed two trends: (1) the unfavorable aspects were in the minority; and (2) the unfavorable aspects were entirely in the realm of the students' opinions. For example, the completely favorable aspects involved tangible and objectively measured facets of the Program, such as selection, place-

ment, interests, and academic achievement. Since no program attains perfection, we may profit by following Darwin's dictum of searching for negative evidence. However, we must not lose perspective, but remember that these adverse comments represent a puny proportion.

These comments deserve careful consideration for the sincerity and cooperation of these students was exemplary. Moreover, since considerable time and effort were involved in every aspect of the Program, negative, as well as positive, findings should be examined.

Concerning the individual student's evaluations of the eight special courses, two were rated low. As was pointed out in a previous section, both courses were taught by the same teacher. These consistently low ratings were due to a clash in personality, methodology, and goals. Though the other six courses were rated favorably there were some adverse comments.

Unfavorable comments which appeared in the committee reports merit consideration since they were endorsed by six people: unawareness of the needs of high school science teachers (7 committees); insufficient counseling (7); lack of instructions in education seminar (7); distractions such as tests and meetings (4); overloading of courses (3); poor communications (3); heterogeneity of background in same class (3); and chemistry inadequate (3).

Recommendations

Our purpose has been to report these findings objectively and to bring them to the attention of the Staff. In the final analysis, they must weigh the pros and cons and judge whether or not these opinions have an emotional or a factual basis.

Moreover, a follow-up-survey of these teachers is in order. After they have returned to the classroom they should be queried concerning the more lasting impact of the Program. This will place our present findings in perspective, and point to the more enduring results.

Conclusion

This evaluation has demonstrated the importance of a scientific approach. Consequently, future modifications and other programs should be evaluated in a similar manner, so that scientific research will replace speculation and opinion in the assessment of educational programs. In addition, this Program has demonstrated that the skills of teachers can be improved by means of a special curriculum and a stimulating atmosphere. This points to two important implications.

The typical teacher's transcript revealed that he was overspecialized in one field. Yet, he was teaching in other fields in which he had little or no background. It would seem, therefore, that college curricula for secondary school science teaching should be revised. A better balance of scientific subjects should be provided.

Secondly, and of equal importance, was the fact that these outstanding science teachers improved significantly in all scientific fields. What then of less experienced teachers who are less capable? Obviously, they need similar programs even more.

Guided by scientific research, the curriculum should be balanced and additional training provided. This should mitigate our present shortage of scientific personnel and increase our potential in the generations to come. Improvement in the teaching profession will be necessary if the United States is to maintain its lead in scientific development. In this framework, the words of Emerson provide a fitting finale: "A teacher's influence endures for eternity."

Bibliography

1. Danon-Boileau, H., "Problèmes Posés par L'Hygiène Mentale des Etudiants." *L'Évolution Psychiatrique*, Vol. LV, 1956, pp. 809–842 (a summarized translation by the writer appears in *Psychological Abstracts*—in press).
2. Ostlund, Leonard A. "College Transcripts and Standardized Tests as Criteria for Graduate Placement," *School and Society*, LXXXVI (Jan. 18, 1958), 41–43.
3. Ostlund, Leonard A. "Occupational Choice Patterns of Negro College Women," *Journal of Negro Education*, XXVI (Winter 1957), 86–91.
4. Ostlund, Leonard A. "Science Teachers Evaluate Science Teachers," School Science and Mathematics, LVIII (Feb. 1958), 125–131.
5. Zant, James H. "A Report on Academic Year Institute for High School Science and Mathematics Teachers," Oklahoma State University (Unpublished mimeographed bulletin, October 1957).
6. Zant, James H. "Modifications in Freshman Mathematics for Engineers," *Journal of Engineering Education*, XLVII (May 1957), 739–744.
7. Zant, James H. "The Mathematics and Science Teacher of Tomorrow," *The Mathematics Teacher*, Vol. L (October 1957), 426–431.

ANECDOTES FOR LIMITS

In trying to give beginning students an intuitive feeling for what happens when a limit such as

$$\lim_{x\to 1} \frac{x^2-1}{x-1}$$

is being evaluated, we often say that one may not let x take the value 1 since the function is not defined at that point. Further, the value at a single point has nothing to do with the limit. However, the function being defined for near values, we may take x close enough to 1 to see what the function is doing near 1. Two anecdotes illustrate the point. The first came from my calculus teacher Prof. Amos Barksdale, North Texas State, the other came from some preacher.

1. I put on my seven league boots and start to town. These boots are such that each succeeding step carries me half the remaining distance to town. I never get to town but I get close enough to do my shopping.

2. Letting x be equal to 1 is like committing sin. We won't actually commit sin, but we will get close enough to see what it's like.

James C. Bradford
Abilene Christian College
Abilene, Texas

Eggs and Physics—A Class Experiment

John Satterly
University of Toronto, Toronto, Canada

This note contains a description of a series of physics experiments on the eggs of the domestic hen. The experiments could be performed by a class of high school students under the supervision of a teacher who could apportion the different experiments to suit his class and the apparatus available. Needed are balances weighing to 0.01 gm., calipers reading to 0.01 cm., screw gauges to 0.01 mm. thermometers to 0.5°C., and hydrometers to 0.005. If the experiments on Moments of Inertia are done a torsion pendulum and a good stop watch are required.

SUMMARY OF SECTIONS:

Part I

1. The Shape of Eggs
2. Mechanics with Eggs
3. Masses and Dimensions of Eggs
4. Overall Specific Gravity of Eggs
5. Specific Gravity of the Shell
6. Specific Gravity of Egg Albumen
7. Coagulation Temperature of the Albumen
8. The Hard-boiled Egg
9. The Thickness of the Shell and Shell Membrane
10. A Little Chemistry
11. The Surface Tension and Viscosity of the Albumen
12. Summary of Author's Results on Hens' Eggs
13. Additional Facts from Special Books.

Part II (to appear in a later issue)

14. Moments of Inertia. Definition and Examples
15. Comparison of Moments of Inertia
16. Hints on the Timing of Vibrations
17. A Convenient Torsion Pendulum and Inertia Frame
18. Moments of Inertia of Eggshells
19. Moments of Inertia of the Whole Egg
20. Summary of Results on the Moments of Inertia of Eggs

We shall suppose that the teacher has brought to class a carton of about a dozen hens' eggs (Grade A, say) and the class having become interested in the novel experiments they are about to do, the eggs are distributed. The students will use the following notes as instruction sheets. The teacher will be active in advice and guidance.

Part I

(1) *The Shape of Eggs*

Everyone is familiar with the shapes of eggs and eggs of different species of birds show great variation in shape as a visit to the nearest hedge-rows in spring or to museums will show. Some eggs are nearly

spherical, some a little broader at one end than at the other and some much more pointed at the one end, i.e., nearly conical. Hens' eggs are usually broader at one end than at the other but sometimes the ends are very nearly alike. The long axis passes through the middle points of the two ends and cross-sections perpendicular to the long axis are very nearly circular. Occasionally eggs are very nearly alike at the two ends and the broadest part just half-way along. The external shape then approximates to that of a prolate spheroid, this being the shape obtained when an ellipse is rotated about its major axis. Any such egg should be kept for the moment of inertia experiment. Useful references to the Shapes of Eggs will be found in a research paper by F. W. Preston,[1] in the magazine *The Auk*, who endeavoured to find combinations of circular arcs to fit the profiles of the eggs of many species. The shapes of eggs are also considered together with the biology and physics of the egg-laying process by Sir D'Arcy Wentworth Thompson[2] in his "Growth and Form" and by J. Arthur Thomson[3] in his "Biology for Everyman." A whole book of over 900 pages on the "Avian Egg" by A. L and A. J. Romanoff[4] of the Research Department of Cornell's Agricultural College in the U.S.A. contains almost an infinity of information on Egg-laying, the Stucture, the Formation of Eggs, Bio-physico-chemical Constitution and the Economic Importance of Eggs.

(2) *The Rotation of Eggs, Eggs as Tops*

At the risk of breaking an egg spin carefully and rapidly with your hands, an unboiled egg on a fairly smooth floor (not on the bench or table top). Note that it rotates sluggishly on its side (i.e. about a short axis) and does not rise on its end. Do it again and now momentarily stop the rotation by a light touch of the hand. When the hand is removed, the egg rotates again. Why? The answer is that while the egg is spinning the liquid interior of the egg gradually picks up by friction the rotation of the shell. Its rotation does not cease when the shell is momentarily stilled. On release of the hand the forces of friction communicate the rotation of the interior back to the shell and the whole rotates. Remember friction in liquids is often called viscosity.

Now spin a hard-boiled egg on the floor. Note that it soon rises and spins briskly on one end (usually the narrower end, but not always so). If momentarily stopped by the hand, it does not again rotate for a hard-boiled egg behaves as a solid body. The rising of the

---

[1] F. W. Preston, "The Shapes of Birds' Eggs," *The Auk*, Vol. 70, April 1955, p. 160.

[2] D'Arcy Wentworth Thompson, "Growth and Form" (Camb. Univ. Press, Cambridge, Macmillan & Co. New York) 2nd Edition, 1942, Ch. XV, p. 934.

[3] J. Arthur Thomson "Biology for Everyman," (J. M. Dent & Sons, London) 1924, Vol 1, Ch. XX, p. 373.

[4] A. L. and A. J. Romanoff, "The Avian Egg," (John Wiley & Sons, New York and Chapman & Hall, London) 1949.

spinning egg on its end reminds one of the behaviour of a spinning peg-top. A further discussion on the mechanics of the spinning tops with a special reference to eggs, will be found in John Perry's "Spinning Tops"[5] and Harold Crabtree's "Spinning Tops and Gyroscopes."[6] It is there deduced that for stability in rapid rotation, the spinning body will set itself to keep its center of gravity as high as possible.

(3) *The Masses and Dimensions of Eggs*

It is just as well to number each egg with a pencil mark that will not rub out nor disappear when the egg is boiled.

Weigh each egg to 0.1 gm. on a balance and note its *mass* both before and after boiling. Measure to 0.01 cm. the length and maximum breadth of each egg and note how far along the length from the narrow end the maximum breadth occurs. If the maximum breadth is a half way along the shape of the egg may be a prolate spheroid. Do this also before and after boiling. Record all measurements and any changes. While the egg is being dimensioned it is convenient to rest it on the top of a ring of metal or wood (e.g., a curtain rod ring). The support keeps the egg fairly stationary and measurements may be made in greater comfort. Repeat the measurements several times. The size of the air space may change during boiling so that the mass may change but little change will be found in the length and breadth. The teacher may now make a table of the masses, lengths and breadths and their arithmetical means found with their average deviations.

(4) *The Specific Gravity of Eggs*

The chief components of eggs, e.g. shell, albumen and yolk, have different specific gravities but we will deal first with the egg as a whole, defining the specific gravity as the numerical value of the density (in C.G.S. units), density being here defined as Total Mass/Total Volume.

(a) Perhaps the easiest way of finding the overall specific gravity of an egg is to make a solution of salt water and to adjust its specific gravity so that when the egg is totally immersed in the brine it neither sinks nor floats. Get three beakers each about four inches in height. Shake up some powdered salt in a beaker of water to make a nearly saturated solution. Put this in one beaker to the left, put distilled water (tap water will do) in a beaker to the right and keep the middle beaker for the egg, adding or withdrawing brine and water until the egg will remain suspended in the solution. This process may take

[5] John Perry, "Spinning Tops," (S.P.C.K., London) 1916, 2nd ed. pp. 68, 98.

[6] Harold Crabtree, "Spinning Tops and Gyroscopic Motion," (Longmans, Green & Co., New York and London), 1909, Ch. 1, p. 6.

some time for the method is sensitive and cannot be hurried. Now measure the specific gravity of the solution with a good graduated hydrometer[7] and attempt to read to the third decimal place. Record the value at once and then check it again. Also measure the specific gravity with a specific gravity bottle (50 cc.). To save time, its empty weight and weight full of distilled water should be done before. If the apparatus is available also determine the specific gravity by the use of Archimedes' principle using a "hydrostatic balance" and plummet (a Westphal balance is convenient).

A brine solution may also be used to measure the specific gravity of hard-boiled egg from which the shell has been removed and also of pieces of the white of egg and the yolk. As these components may absorb salt from the brine they should not be left long in the solution, and you may find that pieces of solid white or yolk may float for a time in a given solution and then sink. The yolk is slightly lighter than the albumen as evident from the fact that if one breaks an egg in a saucer the yolk floats on top of the albumen, and the specific gravities do not change on coagulation for total mass and volume remain nearly constant.

(b) A cruder but much quicker method is to measure the volume of the egg. Take a graduated cylinder into which the egg may be easily inserted (say a 500 cc. cylinder graduated to 5 cc. marks) and partly fill it with water. Read the level of the surface. Try to read the bottom of the meniscus (the teacher will explain what this is) to the nearest cc. Slide the egg gently into the (inclined) cylinder avoiding any splashing. Read the water level again. The difference between the two readings will give the volume of the egg (to the nearest 2 or 3 cc.). As the volume is about 60 cc. this may mean an error of 4 % in the recorded volume.

(c) Another crude method is to use a delicate spring balance with suspended hook or pan. The balance used by the author has a light wire scale pan, it reads up to 75 gm., has a scale six inches long and is graduated to half gms. Put the egg on the pan, record its weight. Now lower egg and pan into water and so find the loss of weight. Apply Archimedes' principle. The loss of weight in gms. is numerically equal to the volume in cc. An error is introduced by the loss of weight of the pan. This may be dermined by a preliminary experiment with the pan only immersed in water. Or, instead of immersing the pan in water, the egg may be suspended from pan (or hook) by a cradle made of a narrow strip of Scotch tape or even of cotton thread.

(d) Greater accuracy is obtained by using a chemical balance as follows: Fit up the left side of the balance *B* (Fig. 1a) with a low stool

[7] My hydrometer reads from 1.000 to 1.200, is graduated to 0.005 and the distance between graduation marks is nearly 2 mm.

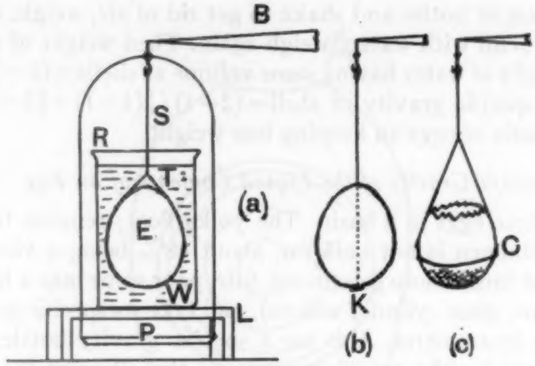


FIG. 1a. Egg *E* suspended by a narrow strip of Scotch tape *T* plus a thread *S* from one arm *B* of a chemical balance and ready for weighing in air and in water contained in a beaker *R* standing on a low stool *L* which strides the scale pan *P*.

FIG. 1b. Hard-boiled egg (or shell) suspended by a single thread from the balance-arm. A knot *K* at the bottom of the thread keeps the egg in position; ready for weighing as in Fig. 1a.

FIG. 1c. The greater part of the shell (plus the fragmentary portions placed within) suspended in a cradle *C* of thread and ready for weighing as in Fig. 1b.

L which strides the left-hand pan *P* and a beaker *R* of suitable size. Suspend the egg with a narrow stirrup of Scotch tape and thread or by several threads forming a cradle, and weigh the egg in air and water. Corrections may be made of the weights of the supports when dry and when wet, the corrections should be small. A variation of the above is to use a long needle to pull a cotton thread, with a large knot *K* at the end through the egg and hang the egg as in Fig. 1b. If the holes made by the needle are very small this can be done with a fresh egg and with the same egg boiled and, if the shell is carefully removed, with the interior of the egg.

(5) *The Specific Gravity of the Shell* (plus its inner membrane)

(a) Take an egg which has been eaten and all the white removed. Replace the removed fragments of the shell within the larger portion as in Fig. 1c suspend by a cradle of thread and weigh in air and water as before. Apply Archimedes' Principle.

(b) Blow an egg, allow it to drain for some time until the interior is reasonably dry. Pass thread through as in Fig. 1b. Weigh. Remove shell from balance, immerse in a beaker of water until all the air has bubbled out, place beaker with egg on stool, attach string to hook of balance and so weigh in water. Apply Archimedes' Principle.

(c) Take several (say six) dried egg shells, crush them to small pieces and use a specific gravity bottle method. In order (1) weigh the dry bottle, (2) weigh the dry bottle plus dry shells, (3) add water

to fill up rest of bottle and shake to get rid of air, weigh. (4) Empty bottle and refill with water, weigh again. Then weight of shells $=(2)-(1)$. Weight of water having same volume as shells $=(4-1)-(3-2)$ Therefore specific gravity of shell $=(2-1)/\{(4-1)-(3-2)\}$. Note that the shells of eggs on keeping lose weight.

(6) *The Specific Gravity of the Liquid Contents of an Egg*

Break three eggs in a basin. The yolks float, remove them. Note that the albumen is not uniform, about 40% being a viscous liquid and the rest much more gelatinous. Stir, pour some into a hydrometer jar (a narrow glass cylinder will do), and take its specific gravity with a sensitive hydrometer. Also use a specific gravity bottle. Take the temperatures for the specific gravity of the albumen is only about $4\frac{1}{2}$% greater than that of water. Careful observations show that the specific gravity of the albumen increases perceptibly (>1%) from outside to inside.

Note as you rinse out the bottle how readily the mixture of albumen and water forms bubbles, whose sections at the walls of the bottle are hexagons and in the interior interfaces are sometimes pentagons.

(7) *Coagulation Temperature of Egg-Albumen—a "Change of State" Experiment*

Pour some of the liquid albumen into a large test tube, provide a thermometer and heat the tube in a large beaker of water. Stir gently. Watch for coagulation partial or complete and take the temperatures at each stage. Repeat two or three times with fresh albumen. The author's experiments indicate that the albumen becomes cloudy just about 55°C., begins to coagulate at 65°C., is nearly all solid at 70°–75°C. and is quite solid at 80°C.

The yolk coagulates at a slightly higher temperature.

Therefore without a pressure cooker, it is not possible to hard-boil eggs on the top of a high mountain. At an elevation of 20,000 feet (6000 metres) the average barometric pressure is $35\frac{1}{2}$ cm. of mercury and the boiling point of water is 80°C. At a height 50,000 feet the atmosphere pressure is only about $9\frac{1}{2}$ cm. of mercury and the boiling point of water is 50°C.

(8) *The Hard-boiled Egg*

Take an egg, weigh and dimension it. Place a beaker of water on the heater. When the water is boiling place the egg gently in the water using a spoon to lower the egg to the bottom or the shell may crack. Stir gently for a time so that coagulation occurs uniformly and the yolk remains central. Boil for ten minutes, cool in cold water and now weigh and dimension again. The weight is often a little less than be-

FIG. 2. A hard-boiled egg cut longitudinally into two halves to illustrate the white W, the nearly spherical yolk Y and the air cell A. Ready for measurement.

fore, the length and breadth remain pretty constant. Remove the shell and weigh it. Place it aside to dry; note the loss of weight. Carefully cut the white W (Fig. 2) of the egg into two halves leaving the coagulated yolk Y intact and in the round. Note and measure the shapes of the contents and the flattening of the white at the broad end due to the original air space (A). The yolk is very nearly spherical for there is a thin membrane (the vitelline membrane) between yolk and albumen and this acts like the tension in a film of a soapbubble. The colour of the yolk varies from pale yellow to orange. If the egg is boiled for a long time the exterior of the yolk becomes darker. Weigh separately the white, the yolk and the shell. If your measurements have been carefully made, check this equation:

Total volume = Volume of White + Volume of Yolk + Volume of Shell, or in algebraical form:

$$\frac{M}{D}=\frac{m_1}{D_1}+\frac{m_2}{D_2}+\frac{m_3}{D_3}$$

where M, m_1, m_2, m_3 are the masses of the whole egg, white, yolk and shell respectively and D, D_1, D_2, D_3 are their respective densities. The check will only be approximate for during the process of weighing evaporation occurs; also the air space has not been allowed for.

(9) *The Thickness of the Shell (and Shell Membrane)*

Take small pieces of the shell (small because the shell is curved) and measure the thickness with a good screw gauge. Repeat several

times. Test to see whether the thickness of the shell varies from the polar regions to the equatorial region. Now detach the shell membrane from the shell and measure the shell thickness again. Also measure the thickness of the shell membrane. This latter is very small and great care must be taken.

The specific gravity of the shell membrane may be measured with a very dilute salt solution as detailed earlier. The membrane is just a little denser than water.

(10) *A Little Chemistry*

Put an egg shell, say two thirds of it, in dilute hydrochloric acid. Vigorous effervescence of gas occurs. After a time the action slows down but if sufficient acid is present the shell eventually totally dissolves and the shell membrane will detach itself as a bag. The addition of a little nitric acid hastens the solution of the shell and the nitric acid turns the shell membrane orange colour. Remove the shell membrane from the solution, wash well and place in cold water. It sinks. It it floats it likely has a small air bubble on it. Analysis shows that the shell is nearly all calcium carbonate, i.e. it has the same composition as native chalk and limestone.

(11) *The Surface Tension and Viscosity of Egg Albumen*

This section is given for completeness of the story; it is too difficult for the student to perform. The surface tension is not easily measured but it could be done by the capillary tube method or more easily by the ring method as in DuNouy's Ring Tensiometer. Romanoff states that the surface tension is about 53 dynes per cm. That of water, benzene and soap solution are 73, 29 and 25 dynes per cm respectively. The surface tension of the yolk is about 17 dynes per cm.

The viscosity of egg albumen may be measured with an Ostwald viscometer of fairly large bore or a Michell's cup and ball viscometer. According to Romanoff it is about 50 times that of water and varies considerably at different distances from the center of the egg. The yolk is about eight times as viscous. The viscosities of ordinary glycerol (specific gravity 1.255) and olive oil at 20°C. are respectively 850 and 85 times that of water.

(12) *Summary of Some of the Author's Experiments*

About twenty hen's eggs (Grade A) bought in Toronto in the early months of the year for household purposes yielded the following results: The ± sign indicates the average deviation from the arithmetic mean.

Mass of egg, 62.5 ± 3.3 gm.
Mass of shell, 6.5 ± 0.6 gm. (shell loses about a gm. as it dries)

Mass of white and yolk, 56 gm. (the white weighs about twice the yolk)
Length of egg, 5.94 ± 0.25 cm. } (note the greater
Breadth of egg, 4.30 ± 0.10 cm. } variability of the length)
Thickness of shell (plus shell membrane), 0.037 ± 0.001 cm.
Thickness of shell membrane, from 0.003 to 0.004 cm.
Specific gravities: Whole egg, 1.055 to 1.075
The albumen (liquid or solid), 1.045
The yolk (solid), 1.035
The shell (plus membrane), 2.1 to 2.2
The shell membrane, 1.005

To show that seasonal variations may occur I give some results on 15 Grade A eggs bought in November and December. Mass 59.4 ± 3.5 gm., length 5.8 ± 0.2 cm., breadth 4.3 ± 0.2 cm., mass of shell 6 ± 1 gm., mass of white 37 ± 2 gm., mass of yolk 17 ± 1 gm. Yolk nearly spherical, length 3.3 ± 0.1 cm., breadth 3.1 ± 0.01 cm.

(13) In his book Romanoff gives (p. 105) the following data for the standard hen's egg in the U.S.A.

Weight 58.0 gm.
Volume 53.0 cc.
Specific gravity 1.09
Long circumference 15.7 cm.
Short circumference 13.5 cm (hence breadth = 4.3 cm.)

$$\text{Shape index:} = \frac{\text{Greatest breadth}}{\text{Length}} = 0.74$$

Surface area = $68.0\ \text{cm}^2$.

The shell is porous to allow the passage of air in and out; the pores are oval in shape having dimensions of about 0.025×0.015 mm. and occur to the extent of about a hundred to the cm.^2, there being a greater concentration at the blunt end where the air cell also occurs.

Romanoff also gives approximate formulae for weight and volume in terms of length and breadth. If the shell has the shape of a prolate spheroid of major and minor axes a and b, mathematics proves that the

$$\text{volume} = \frac{4}{3}\pi ab^2$$

and the

$$\text{area} = 2\pi b^2 + 2\pi ab\,\frac{\sin^{-1} e}{e} \quad \text{where} \quad e^2 = (a^2 - b^2)/a^2$$

$$= \frac{4}{3}\pi b(2a + b) \text{ approximately.}$$

(Part II of this article will appear in the April 1959 issue.)

Chemistry

The Pivotal Science in a Liberal Education

Frank E. Brown*

Professor of Chemistry, Iowa State College, Ames, Iowa

During the golden age of Greece the education advocated by Socrates, Plato, Aristotle, and their contemporaries was for the ruling class but not for the much more numerous slaves who served their cultured masters. In Rome the liberal arts (artes liberalis) were the highest arts, those which none but freemen might pursue. In the middle ages, the seven branches of learning: grammar, logic, rhetoric, arithmetic, geometry, music and astronomy were the liberal arts.

Today, science, history, philosophy, etc., are included in the lists of courses which may be presented to fulfill the requirements for the degrees bachelor and master of arts. These degrees are generally believed to represent adequate preparation for living a good life but are not expected to furnish much aid in earning a living. Science need not be required and the requirement of a course in a particular science as chemistry would certainly be unusual.

For many generations this was the only education offered in the schools. Common laborers imitated the more experienced members of their group. Skilled workmen received their training from a master of a craft to whom they were apprenticed. A century ago few men received any education beyond grade school. Those whose education went beyond this were expected to live on the income from inherited property, or to belong to learned professions such as: preaching, teaching, or practicing law or medicine.

About a century ago, education of workers in the United States was accelerated by the establishment of state colleges to teach agriculture and mechanic arts. At first some of the courses differed, but little from the instruction given by a master to his apprentices. The difference between education for a profession and that for an artisan was profound. But the gap between the two was closed by advances from both sides.

Cultured successors of Priestly, Franklin and Jefferson found that the science which they had learned as inquisitive gentlemen could be used in improving processes in industry or producing saleable articles. The more intelligent artisans asked why some tedious old routines must be followed. Investigation often found new, shorter and better methods. It was not long until some of the scientists had considerable difficulty in determining the boundary line between inquisitive gentlemen and acquisitive artisans.

---

* Dr. Brown is the 1958 winner of the Scientific Apparatus Makers $1000 Annual Award in chemical education.

However, well within the twentieth century, pure chemistry was a much more gentlemanly occupation than applied chemistry, and two kinds of education were labelled liberal or cultural education, and vocational education. Ardent partisans of liberal education tried to follow the curriculum, then centuries old, so closely that those who enrolled in it must learn the Greek and Latin languages. Just as bigoted, others made job surveys to determine the minimum essentials needed in each vocation, set up a curriculum to impart these essentials, taught the courses, called the process education, and awarded a diploma.

This purely vocational education is a liberal or complete education for those whose aspirations do not reach beyond the acquisition of money and property and the domination of others in every way in which money and property can exert their influence. Of course, Americans are free and are entitled to a liberal education even by the Roman definition, and in this republic both earning a living and living a good life are desirable.

Just what is meant by the good life depends on: the era, the place, the circumstances, and very much on whether the one who prescribes the limits sets them for himself or for some hypothetical hero. Most Americans hope that their children will be more successfully acquisitive and domineering than the average. They do hope that the acquisitions will be made in an approved manner, and that influence will be exerted by attractive leadership not by coercion. The successful life, if not necessarily the good life, is measured all too often in terms of: material wealth; and social, industrial or political prominence.

When the good life is described for an impersonal hero, unselfiish service for others is almost always a prominent feature. The education which is designed to produce a good life would be indicated by the title cultural education. The dictionaries define culture as disciplined, refined, characterized by mental and moral training.

This mental and moral training, frequently called a liberal education, will be called cultural education in the remainder of this paper. If the vocational education prepares one to do only the thinking and perform only the manipulations required during the forty working hours in a week, the cultural education must furnish all additional schooling which the person is to receive. (People are educated by what they encounter outside class rooms as well as what occurs in assigned classes.) The title of this paper infers that it is desirable to include science and *especially chemistry* in the training of every American.

Any ordinary citizen of the United States is likely to be interested in the fields suggested by the words: government at the local, state and national levels; investments; family; neighbors; church, clubs

and lodges; recreation and social contacts.

Governments at the city level deals with: softening hard water; chlorination of water to kill disease germs; fluoridation of water to improve the enamel of the teeth; sewage and garbage disposal; chemical control of mosquitoes; control of rodents by poison; and ordinances requiring sanitary precautions, all of which involve chemistry. State governments deal with; blood tests for those accused of drunken driving; use of truth serum for those accused of crime or tranquilizers for mental patients; unrestricted sale of sleep inducing drugs; labeling of drugs, poisons, mixed feeds or fertilizers; safeguards for human foods; control of contamination of the atmosphere or of the water of streams and lakes; and methods for surfacing roads; each of which raises questions whose answers involve chemistry.

The national government must deal with the questions raised by the topics: atom bombs; hydrogen bombs; radioactive fall out; effect of radiation on human tissue and heredity; special metals, alloys and fuels for rocket engines; conservation and stockpiling of necessities we do not produce; and public funds to explore the use of oil shale and low grade ores. Some knowledge of chemistry would aid in judging the value of the laws introduced to solve the questions raised.

Investments should be made in companies whose businesses will not be destroyed by changes in technology. Chemical processes carried out in factories have destroyed large industries. Dyes were formerly derived from plants or animals. Extracts from plants and animals formerly provided the drugs, flavors and perfumes in widest use. Now a large fraction of the dyes, drugs, flavors and perfumes are made from coal tar, petroleum, and byproducts or wastes from totally unrelated industries. For instance, vanilla is made from lignin extracted from wood in preparing pulp to make paper.

The fibers in wool, cotton, linen, silk and other natural products are subject to strong competition from factory made fibers such as: rayon, nylon, orlon, dacron, teflon, perlon, dynel, saran, velon, terylene, acrilan, and lumnite. Plastics are replacing leather. More articifical rubber than natural rubber is used in the United States. Wood blocks, and brick formerly used to surface streets were replaced by the artificial mineral, concrete made from cement which in turn is receiving real competition from bitulithic concrete. Coal almost completely replaced the fuels in use two hundred years ago but is now yielding to oil and gas.

In the near future atomic energy looms as a threat to all other known sources of energy. Every discovery of a new source of supply for something the human race desires produces new and prosperous businesses. If the new businesses satisfy a need formerly supplied less

satisfactorily or at a higher cost, formerly prosperous businesses decline or fail. Businesses depending on chemistry frequently supplant those which depend largely on natural products.

Each person and his family: breathes air which may be unnecessarily contaminated; drinks water which has been treated by adding chemicals or perhaps should have been so treated and has not been; eats foods sprayed by poisons while growing, preserved by chemicals while stored and bleached and colored by chemicals to make them more attractive.

Some of their clothing is made from artificial fibers and a few persons are allergic to the components of some of these fibers. Almost every act from the early morning look at the illuminated dial on the clock to see if one more nap is possible, to the sleeping pill at night is concerned with a chemical product. In life this lasts from the first soothing baby powder to the last swallow of tonic in old age. The family should know that many of the courses taught in high schools cannot serve as a basis for many college curricula.

Careers in engineering, science, medicine and other learned professions must have prerequisites in languages, both English and foreign, mathematics, science and other courses which demand mental exercise and growth. These must be taken in high school or the college curriculum cannot be completed in four years.

One has neighbors and most Americans join churches, clubs and lodges. In these relationships a consideration of the effects of the new chemicals for weed killing, soil sterilization, insect control and extermination of rodents must be appreciated. Some have a very selective action and their use has little effect on any one but the user. Others may drift to the domain of a neighbor and destroy ornamental plants and even trees, or soil fumigants may kill birds and pets. Insect sprays may kill mosquitoes but also wipe out stands of bees and prevent the production of clover seed.

Churches, clubs and lodges are always refinishing, repairing, refurnishing and redecorating, as well as occasionally building anew. The newest material is not always the best. Some knowledge of the materials, their resistance to corrosion, deterioration in the presence of light, heat, moisture or other special conditions is advantageous. An appreciation of the possibilities of chemical effects is advantageous if it is only enough to know what investigations should be made before contracts are signed or installations are made.

Recreation can involve treatment and protection of guns; equipment for fishing; boats; motors; motor fuels; golf equipment; clothing; shoes and many other such items. Social gatherings are occasions for discussions of the events and materials which are of current interest. Those who understand even a little of the chemistry involved

in these subjects are heard with respect on such occasions.

Up to this point the ability to understand the most common events around us has been stressed. More important even than this is the effect which the study of chemistry can have on the student. Many desirable factors important in a good life cannot be taught directly. They are the results of previous living.

Such physical qualities as health, muscular strength and coördination, and the power to use them, as Kipling says, "long after they are gone" cannot be transmitted by written page, word of mouth or even example. They are byproducts of activities which must be carried out by the one who develops the desired quality. In developing physical qualities, the mental attitude of the recipient is not always important. Both galley slaves rowing in the triremes and the Greek youth winning laurel wreaths in the Olymphic Games acquired strength and stamina; though one exercised under the lash of a hated oppressor and the other proudly and willingly prepared himself to win glory for his city.

Likewise, some moral and spiritual qualities cannot be taught. Parents, teachers, and friends may inform, exhort and set examples, but cooperation with others, ability to reason and make choices or decisions, firmness for the right in the face of opposition, persistence, and truthfulness and honesty come from within and are by-products of correct behavior.

Classes whose members only read books, sit in chairs and talk have far less opportunity to exercise their wills and consciences than the students who work in laboratories, make their own observations, report them, and draw their own conclusions from what they have seen. Each student must repeat an experiment to confirm his first result. Disagreement between successive results must be due to lack of care on his part. Only he and nature participate in the test. Even honesty and truthfulness can be found and rewarded.

Many beginners in chemistry know that copper salts in solution react with sulfides to form an insoluble copper sulfide which is about two-thirds copper by weight. Very few know that when elementary sulfur and metallic copper are heated together to red heat, the sulfide which forms is about four-fifths copper. When a mixture of copper and sulfur are heated, the careful, honest students find ratios of copper to sulfur which seem impossible. They are very humble and apologetic when they report.

In almost any large class, a few find that the copper sulfide weighs one and one-half times what the copper weighed. When reports are all in and explanations are completed, the whole class has experienced some moral development. The increase in weight due to dissolving a wire in nitric acid and evaporating until only a dry solid is left is due

to the oxygen in the oxide which forms. Very often iron wire is used. If silver wire is given instead of iron wire to those whose previous results have been too good to be true, their correct result should be about one-sixth what one could calculate.

A teacher is happy when the students who receive silver wire report good results, but sometimes reports would be good if the silver wire were made of iron. Few beginners in chemistry can be provided with apparatus good enough to secure highly accurate results. They, as well as their instructors, should realize this.

The instructors should know the order of accuracy possible and if all legitimate errors push the experimental results in one direction, the instructor should know on which side of the calculated result the careful, honest experimenter should report his experimental results.

For instance, when magnesium ribbon is burned in a porcelain crucible to produce magnesium oxide, three sources of error cannot be avoided. A small amount of the light white powder is carried away by air currents. Some oxygen is taken from the crucible not from the air and adds no weight and some magnesium united with nitrogen.Oxygen adds two-thirds the weight of the magnesium, nitrogen adds only two-fifths.

Any student who gets the exact result does not weigh carefully and the magnesium oxide cannot be heavier than the calculated value. When mixtures of unknown compositions are given to large groups of students in qualitative analysis, an observer can tell which ones are accustomed to making observations and drawing their own conclusions.

Those who have always depended on others to help make decisions show the mental agony they are suffering. A term of qualitative analysis is a wonderful training in self-reliance, and it affords many opportunites for the development of intellect and character.

The recent discoveries of scientists have been so numerous, and have changed our way of life so much that some of those concerned with moral and social and spiritual affairs have asked for a moratorium in science so that the other phases of life can catch up. Of course, there will be no moratorium. These would-be delayers of progress declare that they have no device equivalent to the scientific method by which their fields can be rapidly developed.

It is true that they cannot isolate a small quantity of humanity; put it under controlled conditions; add, as desired, measured amounts of inducement or temptation; and quantitatively determine the changes effected. Really, the most important part of the scientific method is not the way experiments are conducted but the attitude of the people who conduct the experiments.

The scientific attitude includes at least the following principles:

1. There are scientific laws which are the best statements we know of the ways in which nature behaves.
2. Experiments can be made to find additional behaviors which must be carefully and honestly reported.
3. An honest, earnest effort must be made to find accord between the new observation and the accepted laws and no changes in natural laws are made until necessary.
4. As soon as new facts prove an old law is defective, it must be modified to include the new facts or perhaps completely abandoned and a new statement or statements which include all known facts must be formulated. It is evident that Americans, English, French, German, and Russian scientists can see the same scientific facts even when they try to keep their discoveries secret. If men in other fields would adopt the scientific attitude their agreements would be more frequent and the advances in their fields of endeavor would be more rapid.

All Americans are free persons. Each one of them is entitled to a liberal, a complete education. A complete education would fit him to meet his every obligation as a citizen of a republic and certainly would enable him both to earn a living and live a good life.

He should be a competent workman either manually or professionally, that is he should be vocationally efficient. He should also understand the world around him outside of his occupation. The cultural part of his education should provide this understanding.

This world is partly material. The material part of his surroundings is presently developing more rapidly than the social, moral and spiritual fields. The reason for this is the scientific method which is now applied only to materials and energy. Unmodified, it probably cannot be applied to the metaphysical fields but the most important feature of it is the scientific attitude. This is the attitude which scientists have regarding the laws of nature and how they can be improved.

This single-minded unprejudiced search for facts and the formulations of the widest possible agreements of these facts into the nearest approaches to truth we can make can be transferred to every one of the other fields in which life is lived.

Every citizen of a free country should study a science which shows how every phase of life should be approached if rapid progress is to be made. The really dangerous people belong in two extreme classes: those who believe that everything old is good because it has survived; and those who believe that everything accepted from the past is bad because there was some evil in all of the past.

FOAM IS USED IN NOSE CONES

A sphere of urethane foam about the size of a basketball and capable of withstanding impacts up to 45,000 times that caused by the force of gravity is being used to package sensitive recording instruments carried aloft in the nose cones of Thor and Atlas missiles. The Du Pont Company here said the sphere consists of an outer shell of hard foam surrounding a core of soft foam in which the instruments are embedded. The entire foam unit protects the equipment from vibration and shock, from launching to the time it is returned to earth.

Central Association of Science and Mathematics Teachers

REPORT OF THE FIFTY-EIGHTH CONVENTION

NOVEMBER 27–29: CLAYPOOL HOTEL, INDIANAPOLIS, INDIANA

I. BOARD OF DIRECTORS MEETING

THURSDAY, NOVEMBER 27, 1958, 4:00 P.M. (EST), LOUIS XIV ROOM

Roll Call: Officers: Panush, McCormick, Soliday, Kennedy.

Board Members: Ayre, Conrey, Sister Evarista, Gourley, Grubbs, Hach, Hardy, Read, Shetler, Sistler, Wren.

Journal Officer: Mallinson.

Committee Chairmen: Gross, Meyer, Otto, Sprague.

President Panush expressed his appreciation for the excellent work done by various individuals and committees in preparing for the convention. He mentioned Gross, Grubbs, Meyer, McCormick, and Otto, emphasizing the importance of the latter two.

The minutes of the spring board meeting were approved as distributed.

Reports of Standing Committees:

Nominating Committee: Mr. Meyer stated that since the Secretary was a nominee for Director and had asked that he not be involved in the counting of votes the counting had been done by James Doe, Detroit Country Day School, Birmingham, Mich. and Cora Simon, Western High School, Detroit, Mich. under the supervision of Harold Burch, Highland Park, Mich. and the chairman. Early organization of the Nominating Committee was urged since numerous deadlines must be met during the year. After considerable discussion of the time and manner of reporting the election results it was moved by Gourley, seconded by Read that the Board hear the announcement at the first Board Meeting of the candidates elected, the number of votes cast for each not being announced. The motion was amended by Ayre to allow the official count to be made available to the Board, seconded by Sistler. The amendment was carried. The motion as amended was carried. Meyer then read the list of successful candidates—President: Clyde T. McCormick; Vice-President: F. Lynwood Wren; Directors: K. Eileen Beckett, Robert A. Bullington, Joseph Kennedy, R. Warren Woline. Discussion followed on several matters related to this committee's work, including: voting materials, composition of committee, and notification of winners and losers. Mr. Panush directed Mr. Meyer to notify winners.

Local Arrangements Committee, General Coordinator: Mr. Otto announced several room changes. He acknowledged the fine work of the various sub-committees. Since Indianapolis had not decided to remain on fast time until the program had been printed the time problem had been unavoidable.

Policy and Resolutions Committee: This report had been mailed to Directors earlier. Mr. Gross read the following statement which his committee presented as the philosophy of the Association:

> "The Central Association of Science and Mathematics Teachers believes that student interests and abilities in science and mathematics must be continually developed and utilized at all levels of education if we as a nation are to keep our high standing in scientific achievement and leadership in the world. The Association stands for improving the education of all our children. Such education should meet the general educational needs of all students, and the specialized needs of the able and talented students. This can best be done through the very highest quality teachers, teaching methods, and teaching facilities. Because of these beliefs the Central Association of Science and Mathematics Teachers is dedicated to the continual improvement of education in both science and mathematics."

It was moved by Wren and seconded by Grubbs that the Board adopt this statement as our philosophy. Motion carried. Mr. Gross then read the aims of the

Association as seen by his committee. These are:

1. To assist and encourage the teachers of science and mathematics on all levels of instruction.
2. To promote new ideas for the improvement of teaching, as well as analyze and publicize the best present classroom practices in science and mathematics education, and, to provide ideas as to how science and mathematics may be more closely correlated in the classroom.
3. To provide media of exchange of ideas among science and mathematics teachers. These include our Journal, Convention program, published materials, and personal contacts at meetings.
4. To assume the responsibility for determining and dealing with those problems which are unique to the extent that joint action of science and mathematics teachers is needed to formulate the most effective action.
5. To provide encouragement to qualified young people toward preparing for a career in teaching science and/or mathematics.
6. To cooperate with other professional organizations to strengthen our schools, to improve teaching conditions, curriculum, and salaries.

Read moved that we approve this list of aims, Wren seconded, motion carried. Mr. Gross read the following resolutions:

Since the Central Association of Science and Mathematics Teachers is a unique organization in that it serves two related fields, science and mathematics, be it resolved:

1. that the efforts of the Association be aimed toward stressing the interdependence of science and mathematics and toward giving a type of service to education which other organizations would find difficult to offer.
2. that a real effort be made to identify problems which need attention which are common to both the science and mathematical areas, and,
3. that this Association assume the responsibility and leadership for helping solve these problems by thorough and well formulated studies with recommendations for action followed by active dynamic work to bring about the needed improvement.
4. that the Association participate actively in the efforts to improve the science and mathematics teaching in our schools.
5. that the Association give its wholehearted support to any organization or group making studies in either or both the science and mathematics areas, and that the Association make every effort to inform the teachers, administrators, and the public of these studies showing how they can strengthen our educational system.

It was moved by Read, seconded by Ayre that these resolutions be approved. Motion carried.

The meeting was adjourned at 5:30 P.M.

II. ANNUAL BUSINESS MEETING

FRIDAY, NOVEMBER 28, 1958, 10:15 A.M., RILEY ROOM

The meeting was called to order by President Panush. Mr. Panush urged that suggestions for nominees be made to the nominating committee at the convention or shortly after.

Nominating Committee: Mr. Meyer announced the new officers and directors as reported in Part I.

Policy and Resolutions Committee: Mr. Gross read the aims, philosophy, and resolutions prepared by the committee and accepted and approved by the Board.

Mr. Panush reported that Convention expenses were paid in part by the Indianapolis Chamber of Commerce and the Indianapolis Convention and Visitors Bureau. He expressed appreciation to Mr. Grubbs for his help in this matter.

Constitution Revision Committee: Mr. Wren read correction to the By-Laws, Article III, Sections 1, 3, and 4 making the Secretary and Historian pattern consistent. These corrections were published in SCHOOL SCIENCE AND MATHEMATICS in March and April, 1957. Mr. Wren moved that this correction be approved, Mr. Peak seconded. Motion carried.

Mr. Panush thanked the unsuccessful candidates for permitting their names to be used in the election.

The meeting was adjourned at 10:45 A.M.

III. BOARD OF DIRECTORS MEETING

SATURDAY, NOVEMBER 29, 1958, 2:40 P.M., LOUIS XIV ROOM

The meeting was called to order by Mr. Panush.

Affiliation with American Association for the Advancement of Science: Mr. Mallinson reported that the A.A.A.S. Committee on Affiliation acted favorably on our application for affiliation. This recommendation will be passed on to the Board of Directors (A.A.A.S.) who in turn will present them to the A.A.A.S. Council for final action.

SCHOOL SCIENCE AND MATHEMATICS*:* Mr. Mallinson said that while he was listed as the Editor he would like to give Mrs. Mallinson credit for having done a major part in producing the *Journal.* A substantial improvement in the number of papers available for publication during the past year has allowed the editors much more flexibility in planning the *Journal.* The editor requested permission to publish occasionally excellent articles that have been published years ago in other journals, but have not recieved suitable recognition. It was moved by Conrey, seconded by Sistler that such permission be granted. Motion carried. Mr. Panush expressed the appreciation of the Board to Mr. Mallinson for his fine work on the *Journal.*

Policy and Resolutions Committee: Mr. Gross recommended for consideration of the Board the following items:

1. That the Policy and Resolutions Committee schedule a meeting previous to the annual spring board meeting to study and forumlate policies and recommendations for the Board to consider at the spring meeting. Reimbursement for this meeting should be on the same basis as for Board meetings.
2. That details of the Convention program should be handled by those in charge of the Convention, and in case major policy decisions are needed, they can be handled by the Executive Council. More of the time at the spring Board meeting should be devoted to discussion of Association problems rather than details of the Convention.
3. That nominees for committees, Board, and officers should be informed of their responsibilities and duties before accepting their appointment.
4. That all committee reports be in the hands of the Board members a minimum of two weeks prior to the announced Board meeting at which the report is to be considered.
5. That the chairman of the Policy and Resolutions Committee (unless a member of the Board) attend all Board meetings (with no vote, and no voice except as called on by the Board) and be reimbursed on the same basis as a regular Board member.

*6. That student memberships for full time college and secondary school students be made available at $2.50 per year.

*7. Consideration be given to starting a newsletter of items of a more personal nature about the members.

8. That, since additional help in science and mathematics is being added in many schools and state departments in the form of consultant service, the Association consider this as a possible problem to analyze and suggest ways of organizing and implementing such services.

*9. That a study be made by an appointed committee to determine why

high school pupils take science and/or mathematics. That the study be formulated in such a way that it will make a real contribution to science and mathematics education.

*10. That a committee begin work on determining what types of abilities, psychological, and physical, are needed for success in science and mathematics.

*11. That the Board devote time to discussing other ways of implementing the "Report of the Projects and Research Committee—1956."

These were approved with item 6 revised from the original form to read as given.

President Panush acknowledged the fine work of Mr. Sprague and expressed his deep appreciation of it.

Committee on Public Relations and Publicity: Mr. Sprague distributed copies of his report. This outlined activities of his committee during the past year and made specific recommendations regarding continuation of these activities. He urged every member of C.A.S.M.T. to publicize the organization and its convention at every opportunity.

Mr. Panush then turned the meeting over to Mr. McCormick. Mr. McCormick's first suggestion was that a longer period should be available to the Board for this session.

Report of Treasurer and Business Manager: Mr. Soliday's report was brief due to the limited time available. He proposed, Wren moved, and Grubbs seconded that the spring Board meeting be scheduled for two full days and that travel expenses be paid only to those who attend the entire scheduled meeting.

Report of Yearbook Editor: Mr. Shetler distributed a financial statement for the 1958 *Yearbook.* This report showed that more than 8000 copies were printed and that a profit of about $156 was realized. Mr. McCormick expressed appreciation for excellent work on the *Yearbook.*

Mr. McCormick had to leave the meeting and Mr. Wren presided.

Membership Committee: Mr. Kennedy reported the membership is now about 1400. This is an increase of 33% over two years ago and is the highest total ever reached by CASMT.

Mr. Wren raised the question of expenses for invited general session speakers. It was pointed out that no money is ever made available for this purpose.

A brief discussion of the convention date ended the meeting.

Meeting adjourned at 4:30 P.M.

Respectfully submitted,
JOSEPH KENNEDY
Secretary

* From "Report of the Projects and Research Committee—1956."

NEWBORNS ARE BETTER SURGICAL RISKS THAN OLDER BABIES

The best time to perform surgery on a newborn infant is within the first three days of its life.

The younger the infant, the less disturbing will be a major surgical procedure. The infant is in excellent nutritional state with high levels of hormones and inherited antibodies circulating in the blood during the first three days of life.

In addition, newborn babies are less affected by pain and require smaller amounts of anesthetic agents. They also recover rapidly.

However, after three days have elapsed from the date of birth, surgery should be suspended until the infant is two weeks old. The intervening time is a period of transition in the life of a newborn. The infant, at this time, is losing weight, and has a sluggish adrenal response.

Problem Department

Conducted by Margaret F. Willerding

San Diego State College, San Diego, Calif.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem sent the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the Department desires to serve her readers by making it interesting and helpful to them. Address suggestions and problems to Margaret F. Willerding, San Diego State College, San Diego, Calif.

SOLUTIONS AND PROBLEMS

Note: Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Solutions should be in typed form, double spaced.

2. Drawings in India ink should be on a separate page from the solution.

3. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

4. In general when several solutions are correct, the one submitted in the best form will be used.

LATE SOLUTIONS

2635, 2636, 2637, 2638. *Alan Wayne, Baldwin, N. Y.*

2637, 2639. *J. Byers King, Denton, Md.*

2635, 2636. *Bjarne Skaug, Oslo, Norway.*

2610. *Proposed by A. Elliott, San Diego, Calif.*

Given 12 balls, 11 of which are identical and one of which is either lighter or heavier than the others. Find the odd ball and determine whether it is light or heavy using only 3 weighings on a simple balance.

Corrected solution by H. C. Torreyson, Prospect Heights, Ill.

For the purpose of identification number the weights 1–12. Always place the first mentioned group in the left pan of the balance, or vice versa. In all cases the tipping of the balance will indicate whether the odd weight is light or heavy.

Let "unbalanced same as—" mean that the balance is tipped in the same manner as in the indicated previous test. Let "unbalanced oppositely to—" mean that the balance is tipped in the opposite manner as in the indicated previous test.

I. Test 1, 2, 3, & 4 against 5, 6, 7, & 8.
IIa. If I is balanced, test 9 & 10 against 11 & 1.
IIIa. If IIa is balanced, test 12 against 1 to discover if 12 is light or heavy.
IIIb. If IIa is unbalanced test 9 against 10.
IIb. If I is unbalanced, test 1, 2 & 5 against 3, 4 & 6.
IIIc. If IIb is balanced, test 7 against 8.
IIId. If IIb is unbalanced the same as I, test 1 against 2.
IIIe. If IIb is unbalanced oppositely to I, test 3 against 4.

INTERPRETATION OF RESULTS

IIIa determines if 12 is light or heavy.
If IIIb is balanced, 11 is odd.
If IIIb is unbalanced oppositely to IIa, 10 is odd.
If IIIb is unbalanced the same as IIa, 9 is odd.
If IIIc is unbalanced the same as I, 8 is odd.
If IIIc is unbalanced oppositely to I, 7 is odd.
If IIId is balanced 6 is odd.
If IIIe is balanced 5 is odd.
If IIIe is unbalanced oppositely to IIb, 3 is odd.
If IIIe is unbalanced same as IIb, 4 is odd.
If IIId is unbalanced same as IIb, 1 is odd.
If IIId is unbalanced oppositely to IIb, 2 is odd.

If 9, 10 or 11 is found to be odd, IIa will determine whether light or heavy. If 1, 2, 3, 4, 5, 6, 7 or 8 is found to be odd, I will determine whether light or heavy.

2641. *Proposed by Brother Felix John, Philadelphia, Pa.*

Three roots of the equation

$$x^4+64x^3+819x^2+px+q=0$$

are in geometric progression with a common ratio 4. Find the 4 roots of the equation and also the values of p and q.

Solution by Robert A. Atkins, Brooklyn, New York

Let the roots of this equation be represented thus:

$$x_1=r$$
$$x_2=4r$$
$$x_3=16r$$
$$x_4=s.$$

In a fourth degree equation the sum of the roots taken one at a time is the negative of the coefficient of x^3 (in this case, -64); the sum of the roots taken two at a time is the coefficient of x^2 (in this case, 819); the sum of the roots three at a time is the negative coefficient of x (here, $-p$) and the product of roots is the constant term (q). These relations obtain when the coefficient of x^4 is 1. Using these relationships we can formulate two equations:

$$r+4r+16r+s=-64 \qquad \text{(sum of roots)}$$

$$4r^2+16rs+64r^2+rs+4rs+16r^2=819 \qquad \text{(sum of roots two at a time).}$$

Combining terms,

$$21r+s=-64$$
$$84r^2+21rs=819.$$

Solution of these equations gives two sets of roots:

$$x_1=r=-3 \qquad x_1=r=-\frac{13}{17}$$

$$x_2=4r=-12 \qquad x_2=4r=-\frac{52}{17}$$

$$x_3=16r=-48 \qquad x_3=16r=-\frac{208}{17}$$

$$x_4=s=-1 \qquad x_4=s=-\frac{815}{17}.$$

To determine the values of p and q, we can take the roots and get the negative of the sum taken three at a time (p) and the product (q), or else multiply out the four factors. In the case of the four integer roots we get the equation

$$x^4+64x^3+819x^2+2484x+1728=0$$
$$\text{where } p=2484 \text{ and } q=1728.$$

In the case of the four fractional roots we get

$$x^4+64x^3+819x^2+\frac{11710348}{17^3}+\frac{114595520}{17^4}=0$$

where

$$p=\frac{11710348}{17^3} \quad \text{and} \quad q=\frac{114595520}{17^4}.$$

Solutions were also offered by M. Barnebey, Tougaloo, Miss.; C. R. Berndtson, Wilmington, Mass.; Hermann Boeckmann, Bloomington, Ill.; Benjamin Greenberg, Brooklyn, N. Y.; J. Byers King, Denton, Md.; Jack E. Poulson, Pocatello, Idaho; and the proposer.

2642. *No solution has been offered.*

2643. *Proposed by Alan Wayne, Baldwin, N. Y.*

As n increases without limit, what is the limit of:

$$(\sqrt{1}+\sqrt{2}\cdots\sqrt{n})/n\sqrt{n}?$$

Solution by Bjarne Skaug, Oslo, Norway

Let n be a quadratic number $=q^2$. The value of numerator is greater than:

$$3\sqrt{1}+5\sqrt{4}+7\sqrt{9}\cdots[q^2-(q-1)^2](q-1)$$

and less than:

$$\sqrt{1}+3\sqrt{4}+5\sqrt{9}\cdots[q^2-(q-1)^2]q.$$

The first sum is obtained by substituting successive integers for q in $2q^2-3q+1$, the second sum is likewise obtained from $2q^2-q$. Using formula for the sum of the first q quadratic numbers and formula for the sum of the first q numbers, we find that the first and the second sum will respectively equal:

$$\frac{2q(q+1)(2q+1)}{6}-\frac{3q(q+1)}{2}+1$$

and

$$\frac{2q(q+1)(2q+1)}{6}-\frac{q(q+1)}{2}.$$

Now we turn to denominator. Remembering $n=q^2$ we find denominator equal to q^3. Dividing each sum by q^3 and going to the limit we find the limit for each quotient equals $\frac{2}{3}$. This then is the limit of our fraction.

Solutions were also offered by M. Barnebey, Tougaloo, Miss.; C. R. Berndtson, Wilmington, Mass.; Thomas MacDowell, San Diego, Calif.; and the proposer.

2644. *Proposed by C. W. Trigg, Los Angeles, Calif.*

Show that for all integer values of x,

$$x^9-6x^7+9x^5-4x^3$$

is divisible by 8640.

Solution by C. Berndtson, Wilmington, Mass.

$$F=x^9-6x^7+9x^5-4x^3=x^3(x-1)^2(x+1)^2(x-2)(x+2)$$

$$8640=3^3\cdot 5\cdot 2^6$$

$x-2$, $x-1$, x, $x+1$, $x+2$ are 5 consecutive numbers therefore one of them must be divisible by 5.

Let

$$x=2k$$
$$F=8k^3(2k-1)^2(2k+1)^2 2(k+1)2(k+1)$$
$$F=32k^3(2k-1)^2(2k+1)^2(k-1)(k+1)$$

if

$$k=2z$$
$$F=256z^3(42-1)^2(4z+1)^2(2z-1)(2z+1)\equiv 0 \bmod (64)$$

if

$$z\equiv 0 \bmod (3) \qquad F\equiv 0 \bmod (27)$$

if

$$z=2H+1 \qquad F\equiv 0 \bmod (27)$$

if

$$z=2H-1 \qquad F\equiv 0 \bmod (27).$$

Let

$$x=2k+1$$
$$F=(2k+1)^3 4(k^2)4(k+1)^2(2k-1)(2k+3)$$
$$F=16k^2(k+1)^2(2k-1)(2k+1)^3(2k+3)$$

by substituting similar to the above we can prove

$$F\equiv 0 \bmod (8640).$$

Solutions were also offered by Robert A. Atkins, Brooklyn, N. Y.; H. C. Torreyson, Prospect Heights, Ill.; and Alan Wayne, Baldwin, N. Y.

2645. *Proposed by John Nayler, Calgary, Alberta, Canada.*

A schoolgirl considers a bus ride "lucky" if the number of her bus ticket contains at least one 7. If the ticket numbers run in full sequence from 0001 to 9999, what is the chance that any one ride will be "luck"?

Solution by Hermann Boeckmann, Bloomington, Ill.

A. There are 19 numbers between 0001 to 0100 that contain at least one 7.
B. There are 9 sets of numbers between 0001 to 1000 of 100 each that contain 19 numbers composed of at least one 7 plus 100 numbers in the 700 series. Total 271.
C. There are 9 sets of numbers between 0001 to 9999 of 1000 each that contain 271 numbers of at least one 7 plus 1000 numbers in the 7000 series. Total 3439.
D. Therefore the chance of drawing a "lucky" number is

$$\frac{3439}{9999}$$

or approximately 34.4% of the time this schoolgirl will consider herself lucky.

Solutions were also offered by C. R. Berndtson, Wilmington, Mass.; M. Barnebey, Tougaloo, Miss.; and Alan Wayne, Baldwin, N. Y.

2646. *Proposed by William W. Johnson, Cleveland, Ohio.*

Solve the equation $\sec\phi + 3\csc\phi = 5.7143$.

Solution by C. R. Berndtson, Wilmington, Mass.

$$\frac{1}{\cos\phi} + \frac{3}{\sin\phi} = 5.7143$$

$$\frac{1}{\sqrt{1-\sin^2\phi}} = 5.7143 - \frac{3}{\sin\phi}.$$

Squaring

$$\frac{1}{1-\sin^2} = 5.7143^2 - \frac{6(5.7143)}{\sin\phi} + \frac{9}{\sin^2\phi}.$$

Cross multiplying and grouping we have

$$-5.7143^2\sin^4\phi + 6(5.7143)\sin^3\phi + (-10+5.7143^2)\sin^2\phi$$
$$-6(5.7143)\sin\phi + 9 = 0.$$

Solving for the roots we have

$$\sin\phi = .439397997$$
$$\sin\phi = .693406902$$
$$\sin\phi = -.993424055$$
$$\sin\phi = .910616530$$
$$\phi = 2.231737 \text{ radians}$$
$$\phi = .766207 \text{ radians}$$
$$\phi = 5.138412 \text{ radians}$$
$$\phi = 1.14477 \text{ radians}$$

STUDENT HONOR ROLL

The Editor will be very happy to make special mention of classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

Editor's Note: For a time each student contributor will receive a copy of the magazine in which his name appears.

The Student Honor Roll for this issue appears below.

2637. *Steven N. Mainster, John P. Simpson, and Fred J. Gordon, Peddie School, Hightstown, N. J.*

2641, 2645, 2646. *Lee H. Mitchell, New Trier High School, Winnetka, Ill.*

2646. *Eugene P. Ericksen, Peabody Demonstration School, Nashville, Tenn.*

PROBLEMS FOR SOLUTION

2665. *Proposed by Alan Wayne, Baldwin, N. Y.*

Determine the triangle whose sides are integers and whose perimeter is $2\sqrt{3}$ times the area of the triangle.

2666. *Proposed by Brother Felix John, Philadelphia, Pa.*

A general wishing to draw up his regiment into a square found by trial that he had 92 men over; he then increased each side by two men, and wanted 100 men to complete the square. How many soldiers did he have?

2667. *Proposed by L. Van Tassel, San Diego, Calif.*

Calculate:

$$\sqrt[\pi]{i}=(i)^{1/\pi}=?$$

2668. *Proposed by J. Byers King, Denton, Md.*

The first eight terms of a series are

$$0, -68, -232, -510, -896, -1360, -1848, -2282.$$

What is a formula for a_n and what is the first positive term of the series?

2669. *Proposed by Lee H. Mitchell, Glencoe, Ill.*

When the reverse of one-third of my age is subtracted from the reverse of half my age, the result decreased by my age nine years ago reversed will be exactly equal to my age in eight years. How old am I?

2670. *Proposed by W. W. Johnson, Cleveland, Ohio.*

A stone is dropped from the top of a tower. When this stone has fallen H feet, another stone is dropped from a point h feet below the top of the tower. The two stones reach the ground at the same instant. Find the height of the tower.

EDITOR'S NOTE: THE EDITOR OF THIS PROBLEM DEPARTMENT IS AGAIN IN NEED OF SOME GOOD PROBLEMS. PLEASE SEND ANY NEW OR INTERESTING PROBLEMS TO YOUR EDITOR.

Books and Teaching Aids Received

COLLEGE ALGEBRA, by Thurman S. Peterson, *Professor of Mathematics, Portland State College.* Cloth. Pages viii+413. 14×21 cm. 1958. Harper and Brothers, 49 E. 33rd Street, New York 16, N. Y. Price $4.00.

FUNDAMENTALS OF DIGITAL COMPUTERS, by Matthew Mandl, *Lecturer in Electronic Technology, Temple University.* Cloth. Pages xi+297. 15×23 cm. 1958. Prentice-Hall, Inc., Englewood Cliffs, N. J. Price $5.00.

QUANTITATIVE CHEMICAL ANALYSIS, by Gilbert H. Ayres, *Professor of Chemistry, The University of Texas.* Cloth. Pages xi+726. 15.5×23.5 cm. 1958. Harper and Brothers, 49 E. 33rd Street, New York 16, N. Y. Price $7.50.

PRELIMINARY EDITION TO INTRODUCTION TO LOGIC AND SETS, by Robert R. Christian, *University of British Columbia.* Paper. Pages vi+70. 15×23 cm. 1958. Ginn and Company, Statler Building, Boston 17, Mass.

MATHEMATICS FOR INDUSTRY, by S. E. Russinoff, *Illinois Institute of Technology.* Cloth. Pages x+565. 14×21 cm. 1958. American Technical Society, 848 E. 58th Street, Chicago 37, Ill. Price $6.25.

FOREIGN LANGUAGE LABORATORIES IN SCHOOLS AND COLLEGES, by Marjorie C. Johnston and Catharine C. Seerley. Paper. Pages vi+86. 15×23.5 cm. 1959. U. S. Department of Health, Education and Welfare, Office of Education, Washington, D. C. Price 35¢.

MINNESOTA'S CHANGING GEOGRAPHY, by John R. Borchert. Cloth. Pages vi+191. 19×27 cm. 1959. University of Minnesota Press, Minneapolis, Minn. Price $4.25 (trade discount), $3.00 (sepcial school discount).

CALCULUS QUICKLY, by William R. Ransom. Paper. Pages viii+60. 14×21.5 cm. 1958. J. Weston Walch, Publisher, Box 1075, Portland, Maine. Price $1.00.

ALGEBRA CAN BE FUN!, by William R. Ransom. Paper. Pages ix+195. 20.5×27.5 cm. 1958. J. Weston Walch, Publisher, Box 1075, Portland, Maine. Price $2.50.

GUIDE TO THE LITERATURE OF MATHEMATICS AND PHYSICS, by Nathan Grier Parke, III. Paper. Pages xviii+436. 13.5×20.5 cm. 1958. Dover Publications, Inc., 920 Broadway, New York 10, N. Y. Price $2.49.

LET'S GO TO A ZOO, by Laura Sootin. Cloth. Unpaged. 16×20.5 cm. 1959. G. P. Putnam's Sons, 210 Madison Ave., New York, N. Y. Price $1.95.

THE STORY OF ANIMALS, by Gaylord Johnson. Cloth. 120 pages. 18×25.5 cm. 1958. Harvey House Publishers, Irvington-on-Hudson, New York. Price $2.95.

THE STORY OF MATHEMATICS, by Hy Ruchlis and Jack Engelhardt. Cloth. Pages 149. 18×25.5 cm. 1958. Harvey House Publishers, Irvington-on-Hudson, New York. Price $2.75.

THE STORY OF DINOSAURS, by Stanley and Barbara Brown. Cloth. 125 pages. 18×25.5 cm. 1958. Harvey House Publishers, Irvington-on-Hudson, New York. Price $2.75.

CAREERS AND OPPORTUNITIES IN ENGINEERING, by Philip Pollack. Cloth. Pages xv+140. 13.5×20.5 cm. 1959. E. P. Dutton and Co., 300 4th Ave., New York 10, N. Y. Price $3.50.

WEATHER IN YOUR LIFE, by Irving Adler. Cloth. Pages 126. 13×20. cm. 1959. John Day Co., 210 Madison Ave., New York, N. Y. Price $3.00.

INTRODUCTION TO MATHEMATICAL ANALYSIS WITH APPLICATIONS TO PROBLEMS OF ECONOMICS, by Paul H. Daus and William M. Whyburn. Cloth. Pages vii+244. 15×23 cm. 1958. Addison-Wesley Publishing Co., Inc., Reading, Mass. Price $6.50.

THE ATOM AND THE ENERGY REVOLUTION, by Norman Lansdell. Cloth. 200 pages. 15.5×23.5 cm. 1958. Philosophical Library, Inc., 15 E. 40th Street, New York 16, N. Y. Price $6.00.

MICHIGAN COUNCIL OF TEACHERS OF MATHEMATICS

The Tenth Annual Conference of the Michigan Council of Teachers of Mathematics will be held at the M.E.A. Camp, St. Mary's Lake, Battle Creek, Michigan, on May 1, 2, and 3, 1959. Registration will start at noon Friday, May 1, and the Conference will close with dinner Sunday noon, May 3.

There will be some general sessions devoted to topics of current and common interest to all mathematics teachers. There will also be numerous smaller discussion groups organized with respect to special subject and grade-level interests. Contemporary movements and trends in mathematical instruction will be discussed, as will some concepts of "modern" mathematics. The program is planned to interest elementary grade teachers as well as teachers in junior and senior high schools.

The camp is pleasantly located on St. Mary's Lake, four miles north of Battle Creek. Recreational facilities are provided, meals are served in the main dining hall, and dormitory type sleeping accommodations are available for about 150 persons. Hotel and motel accommodations are available in nearby Battle Creek for those who prefer them. The charge for the conference (including all accommodations) is modest, and members of the Michigan Education Association are entitled to a substantial discount. In order to be assured of sleeping accommodations at the camp, reservations should be made in advance. Inquiries and requests for reservations may be addressed to Miss Elizabeth N. Scott, Emerson Junior High School, Flint, Michigan.

Book Reviews

MATHEMATICS IN FUN AND IN EARNEST, by Nathan Altshiller Court. Cloth. Pages 250. 13.5×20 cm. 1958. The Dial Press, Inc., 461 Fourth Avenue, New York 16, New York. Price $4.75.

This could be characterized as a collection of essays on various phases of mathematics. In the opinion of the reviewer, there is considerable variation in the degree of mathematical maturity required to follow the various portions of the book; nevertheless this seems an admirable attempt to explain in part what mathematics is and in part what mathematicians do. Many of the extracts would be completely understandable to the average individual with no formal training in mathematics, and would no doubt be enjoyed by such a reader. Other portions are somewhat more advanced.

The chapter titles are indicative of the content, but by no means of the breadth of treatment: Mathematics and Philosophy; Some Sociological Aspects of Mathematics; The Lure of the Infinite; Mathesis the Beautiful; Mathematics and the Mathematician; Mathematical Asides; Mathematics as Recreation. The reviewer was especially pleased with the chapter on the sociological aspects.

This book should by no means be considered a text book; rather, it is a book which should be available in every high school and college library—placed not on the shelves with the mathematics collection, but in the "browsing room" where it will attract the attention of the non-mathematically inclined student. For the student already interested in the subject, this will go far to show him some of the vista which lies beyond. For the purpose suggested, this reviewer believes it deserves a place among the top ranking books of this type now in existence. Is is suggested, however, that the teacher read it himself, and be prepared to answer some interesting questions which will result from making the work available to the student.

CECIL B. READ
University of Wichita
Wichita, Kansas

PHYSICS, by Henry Semat, *Professor of Physics, the City College of New York*, and Robert Katz, *Professor of Physics, Kansas State College of Agriculture and Applied Science*. Cloth. Pages viii+927. 15×23 cm. 1958. Rinehart and Co., Inc., New York, N. Y. Price $9.00.

Physics by Semat and Katz is designed for students of science and engineering who take calculus concurrently. The order of presentation of topics is standard with sections on Mechanics, Heat, Wave Motion and Sound, Electricity and Magnetism, Light, and Atomics and Nucleonics. These topics are presented in a style that asks for a simple acceptance, by the student, of the concepts, definitions, procedures and equations given by the authors. The text rarely suggests how or why concepts came into being and thus rarely calls on the student to use his imagination and reasoning ability to follow arguments about the development of a concept. Indeed where the authors do note the history or development concepts the remarks seem out of place. Examples of this are discussions of planetary motion, curvature of space, and heat as a form of energy. This type of exposition may be a virtue or a fault depending on the teacher who uses the book.

Elementary calculus and vector algebra are introduced and used sparingly in mechanics. Later, in the development of electricity and magnetism, they are used extensively and skillfully wherever applicable. The idea of limiting procedure applied to physical cases is used to define velocity and acceleration in terms of a derivative operation.

Although used, there is no corresponding development of the integral operation as a limit of a sum, but there could have been in the discussion of the center of gravity and the moment of inertia of an object. Wherever vector methods

are introduced, care is taken to show that the vector description or procedure agrees with the physical description or procedure.

There are many sections the reviewer liked particularly. The introduction of the differential equation of motion for a particle moving with simple harmonic motion and the treatment of the solution to this differential equation are excellent. The chapter on properties of matter is put late enough so that students have a good background knowledge to apply to the numerous cases given here. Detailed discussion of such topics as electric polarization in material media and the electric displacement makes probable an understanding of these concepts by terminal students who might never see them discussed again. The sections on Atomics and Nucleonics are almost identical to the corresponding excellent ones in "Fundamentals of Physics," third edition by Henry Semat, an elementary text that does not employ calculus but probably was the basis for the present new book.

"Physics" is brief for the large number of topics discussed. If used properly, I think this text could be a foundation for an excellent, rigorous course, but a book that would require a teacher skilled in detecting and overcoming student weaknesses to make it an effective teaching instrument.

E. W. Friesen
Department of Physics
Indiana University
Bloomington, Indiana

Chemical Calculations, Third Edition, by Bernard Jaffe, *Chairman of the Department of Physical Sciences, James Madison High School, Brooklyn, N. Y.* Cloth. Pages xii+180. 1958. World Book Co., Inc., Yonkers-on-Hudson, N. Y.

This is the third edition of a mathematical Chemistry text which first appeared in 1926 and which has had a wide use. Too many high school teachers dodge the chemical arithmetic thinking it is too difficult to teach; instead, they emphasize descriptive chemistry and thus fail to teach the quantitative chemical laws and principles.

The author starts Part One with the structure of matter and then proceeds to the quantitative relationships which are associated with the chemical formula. From here he proceeds in a progressive manner to the use of valence and to the balancing of equations. He then explains the method of deriving formulas from experimental data, and in turn brings in the concepts of the gram molecular volume and the gram equivalent weight; all of this necessitates the solving of gas law problems. This gradually leads to various types of problems which can be solved by use of the balanced equation. All of the above mentioned problems are arranged progressively according to ten types. The Part One is then concluded with examples of problems from the New York State Regents Examinations.

Part Two deals with more advanced types of problems, such as, the use of the Dumas and Victor Meyer methods for the determination of molecular weight, and the use of boiling point elevations and freezing point depressions as methods of determining molecular weights. Included in Part Two one will also find problems based on Faraday's laws, and on normal and molar solutions.

Part Three has problems based on various chapter topics such as Oxygen and Ozone, Hydrogen, Chlorine and others.

In the final ten pages is an appendix which gives much helpful information.

This problem book is well written and should be of great aid in helping beginning students to solve chemical arithmetic problems.

Gerald Osborn
Western Michigan University
Kalamazoo, Michigan

Thinking about God's World, by Mother Mary Thomas and Sister M. Felicitas. Cloth. 384 pages. 15×22 cm. 1957. Mentzer, Bush and Co., 330 E. Cermak Rd., Chicago 16, Ill. Price $1.98.

KNOWING GOD'S WORLD, by Mother Mary Thomas and Sister M. Columba. Cloth. 384 pages. 15×22 cm. 1957. Mentzer, Bush and Co., 330 E. Cermak Rd. Chicago 16, Ill. Price $1.98.

Thinking about God's World, Mother Mary Thomas, S.S.J. and Sister M. Felicitas, S.S.J. under the direction of Rt. Rev. Msgr. Leo M. Byrnes. and *Knowing God's World*, Mother Mary Thomas, S.S.J. and Sister M. Columba, S.S.J. under the direction of Rt. Rev. Msgr. Leo M. Byrnes, Mentzer, Bush and Co., Chicago, 1957 are science textbooks for grades seven and eight respectively and are part of an elementary school science series.

These texts are well written, well balanced, science books prepared for use in Roman Catholic schools. They are adequately illustrated with photographs and line drawings.

Experiments and demonstrations are provided where appropriate. The presentation is a combination of the historical and experimental approaches. The achievements and problems of science are very effectively described through the use of case histories and biographies.

The content of *Thinking about God's World* includes: scientific method, structure of human body (skeletal, muscular, digestive and circulatory), plants, energy (sun and heat), the universe, matter and fire.

In *Knowing God's World* the content includes: nature of science, animals, human body (respiratory and nervous systems), energy (nature of energy, energy transformation, chemical, electrical, heat, radiant and atomic), wave motion (sound, light, radio and T.V.), and machines.

Both textbooks are concerned with pure science and with the technological applications of scientific fact. Teachers using these books will be happy to see the extensive end-of-chapter materials provided. These include summary statements, questions, additional pupil activities, vocabulary lists, and additional readings.

MILTON O. PELLA
University of Wisconsin
Madison, Wisconsin

MONKEY'S ROCKET TRIP INDICATES MAN CAN SURVIVE WEIGHTLESSNESS

Military scientists here have indicated that man can live in the same weightless condition as that experienced by Little Old Reliable, the monkey rocketed into space in December.

Although the monkey was not recovered, data transmitted by radio throughout the entire flight has led scientists to term the experiment "98% successful."

The monkey's heart rate, blood pressure, respiration, temperature, breath sound and body-motion sound were measured during the 13-minute space flight.

For almost nine minutes, the monkey was in a weightless state and showed no adverse physical change. In fact, the irregular respiratory and heart rates experienced during acceleration returned to normal as it entered the weightless state.